Chapter 6

Economics of Centralized Resource Recovery

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Economics of Centralized Resource Recovery

Introduction

Facilities for the recovery of materials and energy from municipal solid waste (MSW) are both capital intensive and costly. They use complex technologies whose performance is still uncertain and their products are difficult to market. Consequently, there has been considerable interest in various types of financial assistance by the Federal Government for constructing and operating such facilities. Proposals for financial assistance programs have included construction grants, loan guarantees, low-interest loans, operating subsidies, and price supports for products.

This chapter lays the groundwork for analyses of these financial assistance proposals by examining the factors that influence the economics of a resource recovery system. It also evaluates the costs and effectiveness of such proposals. Among the topics addressed are:

- The capital and operating costs of various resource recovery technologies.
- The influence of financing methods on the costs of various systems.
- The revenue potential of materials and energy from the various resource recovery technologies.
- The tradeoff between economies of scale in processing and transportation costs for large resource recovery systems.
- The effects of construction and operating subsidies on resource recovery system costs.
- The interaction of centralized resource recovery with source separation programs and beverage container deposit legislation.

Costs and Benefits of Resource Recovery Systems

The economics of centralized resource recovery for a community or a region represent a balance of the systemwide costs and benefits listed in table 41. Some costs and

Table 41 .—Costs and Benefits of Centralized Resource Recovery

Direct costs
- Planning and design
- Investment in plant and equipment
- Site purchase and preparation
- Transportation and transfer
- Operating labor, maintenance. supervision
- Residue disposal
- Auxiliary fuels

Direct benefits
- Revenues from sale of materials and energy

Indirect costs
- Interjurisdictional coordinat ion
- Loss of flexibility to respond to changed waste characteristics
- Air and water pollution from facility operation including residue disposal
- Health and safety hazards to workers and adjacent population

Indirect benefits
- Avoided cost of landfill or other disposal costs
- Avoided water pollution from landfill or dumping
- Reduced health and safety hazards to workers and population adjacent to landfills or dumps
- Reduced costs to collectors of dumping in controlled surroundings
- Public relations benefits for participating communities and firms

SOURCE O; Ice of Technology Assessment

benefits are direct and appear on the balance sheet for the system. Others are indirect and may not appear but should be considered by public decisionmakers. If the direct costs exceed the direct benefits, the resource recovery plant must charge a price for its service, called a "tipping fee, " to make up the difference. From the public point of view, the tipping fee might be adjusted to account for indirect costs and benefits.

These costs and benefits depend on the factors shown in table 42. Among the more important factors are the quantity and composition of waste in the service area; geographic features of the area to be serviced; the population density, the transportation network, and the weather: the availability of markets for recovered products; the prices of those products; and the number and size of the local governments involved.

Table 42.—Factors That Influence the Costs and Benefits of Centralized Resource Recovery

Geographic factors
- Population density
- Total regional population
- Transportation networks
- Subsurface geology and terrain
- Regional weather and climate
- Local construction costs and labor rates

Political factors
- Number and size of political subdivisions in the service area
- Strength of regional planning or Government agencies
- Organization and ownership patterns of waste collection and disposal

Waste stream characteristics
- Quantity
- Composition
- Seasonal variation
- Existence of source separation programs or beverage container deposits
- Nature of commercial, institutional, and industrial activity

Revenue and credit characteristics
- Prices obtainable for products
- Distance to materials markets
- Availability of energy markets
- Local landfill prices

Technological factors
- Technology used
- Plant size
- Energy product choice
- Redundancy or backup equipment required to process waste and to satisfy energy markets

Financial factors
- Ownership mode (public or private)
- Financing method
- Government incentives or disincentives

SOURCE Off Ice of Technology"Assesment

Among the many economic considerations that affect system design, the three most important are the revenues from the sale of products, the costs of processing, and the costs of transportation. A significant consideration is that some energy products from MSW cost more to produce but can be sold at a higher price. For example, it costs more to produce steam than refuse-derived fuel (RDF), but steam can be sold at a higher price. Thus, a community will not necessarily find the system with the lowest gross processing costs to be the optimal one.

A tradeoff must be considered between transporation costs and the economies of scale of processing in large plants. As larger plants are built, they can process wastes at a lower cost per ton, but the cost per ton for transportation from distant collection points goes up. Since unit revenues from the sale of energy and materials do not depend very much on plant size, the economic optimum plant size depends on the scale versus transportation tradeoff.

In addition to these considerations, the translation of capital investment into capital costs per unit of waste processed depends on the modes of ownership and financing because they influence the effective tax rates and the required return on investment.

In the rest of this chapter, the economic factors that have the greatest implications for Federal policy are examined more thoroughly. However, the following discussion has several noteworthy limitations. First, the economics of centralized resource recovery are sensitive to the conditions that prevail in a region. Thus, the data in this chapter should not be used as a basis for design, analysis, or critique of any particular project. Second, the data base for the analysis is not very firm. Most cost and revenue projections are based on plans for proposed systems in specific regions, and confirmation based on actual experience is very limited. Third, the incomparability among various sources of cost information creates serious problems. Finally, potential revenues are subject to wide variation depending on the strength of scrap material markets and the location of a facility relative to those markets, as well as on the nature of local energy markets.

Processing Costs for Various Technologies

The processing costs for centralized resource recovery include capital and operating costs. They depend on the technology selected, the plant size, the financing method, the ownership mode, local construction costs, and labor rates. The costs per unit of waste processed further depend on the operating ratio, or capacity utilization factor; that is, on the fraction of maximum plant capacity that is actually used on a daily or annual basis.

Capital Investment Costs

Table 43 shows estimates of the capital investment required to construct typical large-scale resource recovery plants with capacity to process a maximum of 1,000 tons per day (tpd) of MSW. The wide variation in investment estimates for each technology reflects the diversity of data sources used, the uncertain nature of preconstruction cost estimates, local conditions underlying each estimate, differences in the way site preparation and other costs are treated by different estimators, and differences in the detailed technical characteristics of each plant. The data in table 43 have been adjusted by OTA to a common basis: plants of 1,000-tpd capacity and early 1979 costs. Costs were updated using the Engineering News Record Construction Cost Index.(1)

Table 43 shows that much different levels of investment are required by the various kinds of resource recovery plants. For example, the two most popular types, waterwall incineration and RDF, differ by a factor of two in capital cost. However, their operating costs also differ and their products have different market values. Thus capital costs alone are not sufficient for selecting the technology with the lowest net cost.

Table 43 also shows that estimates of investment costs in constant dollars for resource recovery plants have increased over time, just as they have for other systems that supply energy or process materials. In part, this reflects the better understanding of full costs as real systems are built and operated; note that waterwall incineration cost estimates, which are based on actual experience, have not increased as have the others.

Scale Economies in Investment Costs

It is characteristic of processing technologies that capital costs per unit of material processed decrease with increasing plant capacity. (Operating costs do so as well. See below.) Some analysts have estimated that economies of scale in resource recovery would be very great. In work done for this study, for example, the MITRE Corporation assumed that economies of scale would exist for plants as large as 10,000 tpd. (See reference 13.) More recent studies by other analysts, however, have found that economies of scale in the capital costs of resource recovery are much less significant than had been anticipated earlier. Gordian Associates found that capital costs per ton processed were nearly constant in the range of 200- to 1,500-tpd capacity for waterwall incineration and in the range of 600 to 3,50O tpd for RDF.(14) Similarly, Black and Veatch, and Franklin Associates found capital costs per ton to be nearly constant above a capacity of about 1,000 to 1,500 tpd.(15)

The capital costs of small-scale modular incinerators also depend on plant size. The Siloam Springs plant is reported to have cost $17,700 per daily ton.(16) It is made up of two l0.5-tpd units. Recently, Black and Veatch, and Franklin Associates estimated that the capital cost for modular incinerators would

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Table 43.—Capital Costs of Centralized Resource Recovery (literature estimates and averages for 1,000"tpd plants)

Technology	Reference	Year	Total capital investment (million dollars) Original year $	1979$	Average in 1979
Waterwall incineration to steam	2	1975	$30.8	$39.3	
	6	1975	3 2	40.8	
	4	1975	23	29.4	$37.2
	3	1976	32	38.2	
	5	1977	36	39.1	
Refuse-derived fuel with materials recovery	6	1975	13.2	16.9	
	2	1975	10.4	13.3	
	8	1975	9	11.5	16.7
	7	1976	14	16.7	
	9 b	1976	10.4	12.4.	
	5	1977	27	29.3	
Refined refuse-derived fuel with materials recovery (ECOFUEL-I1°)	2	1975	17.7	22.6	29.6
	6	1975	28.2	36.5	
Wet process refuse-derived fuel with materials recovery	2	1975	13.5	17.2	17.2
Gas pyrolysis					
• Purox®	6	1975	20.8	26.6	
	2	1975	22.9	29.2	
	11	1975	31	39.6	38.3
	10	1976	37	44.1	
	5	1977	48	52.1	
. Torrax®	2	1975	16.5	21.1	
	10	1976	37	44.1	37.3
	5	1977	43	46.7	
Modular incineration with heat recoveryc	5	1977	21.4	23.3	25.8
	12	1978	27.8	28.3	

[a]Literature estimates inflated to 1979 dollars using Engineering News *Record* Construction Cost Index.
[b]Cost for 750 tpd reported in (9) adjusted to 1,000 tpd using scale factor in reference (8).
[c]Costs for modular incinerators reported as five times the cost of a 200-tpd facility

range from $33,100 per daily ton at 25 tpd to $21,400 per daily ton at 200 tpd.(17) The city of Auburn, Maine, reported estimated capital costs of $35,000 per daily ton at 100 tpd and $27,800 per daily ton at 220-tpd capacity. Economies of scale in capital cost are not expected for this technology above 200 tpd.

Capital Costs Per Unit of Waste Processed

The cost of capital per ton of waste processed is obtained by dividing the annual cost of capital by the tons of waste processed annually. The annual cost of capital can be calculated by multiplying the plant investment cost by a capital recovery factor. The capital recovery factor is a decimal fraction that depends on the rate of return, the amortization period, and the tax rate. (See following section.) Typical values of the capital recovery factor for resource recovery plants range from 0.08 to 0.11. For example, a capital recovery factor of 0.10 corresponds to a payment of 8-percent interest on an investment amortized over 20 years.

The annual tons of waste processable in a facility over a full year is usually only a fraction of 365 times the maximum daily capacity, since the plant will not always operate at full capacity. This fraction, the capacity utilization factor, ranges from 0.40 to 0.90. It is, however, usually taken to be 0.70 to 0.80 for resource recovery plants.

The translation of total plant investment into a capital cost per ton of waste processed can be summarized using the following formula:

$$\text{capital cost (\$ per ton)} = \frac{\left[\begin{matrix}\text{total plant investment} \\ (\$)\end{matrix}\right] \times \left[\begin{matrix}\text{capital recovery factor} \\ \text{(fraction)}\end{matrix}\right]}{\left[365 \text{ days}\right] \times \left[\begin{matrix}\text{maximum plant} \\ \text{capacity} \\ \text{(tons/day)}\end{matrix}\right] \times \left[\begin{matrix}\text{capacity utilization factor} \\ \text{(fraction)}\end{matrix}\right]}$$

For example, a 1,000-tpd plant that costs $30 million, which is used 70 percent of the time, and is financed with an effective capital recovery factor of 0.10 would bear an average capita] charge of $11.74 per ton, calculated as follows:

$$\text{capital cost} = \frac{[\$30{,}000{,}000][0.1]}{(365 \text{ days}) \times [1{,}000 \text{ tons/day}][0.70]} = \$11.74/\text{ton}$$

OTA has estimated the capital costs per ton processed for various resource recovery technologies using averages of the investment data in table 43, an assumed capital recovery factor of 0.1, and an assumed capacity utilization factor of 0.70. The results are shown in table 45.

Impact of Financing Methods and Ownership on Capital Costs

The financial terms available to a resource recovery venture depend on the ownership mode, the risk implied by the uncertainty about the performan~e of the technology, and the risk implied by the uncertainty in scrap revenues. For public ownership, the required rate-of-return is higher if a community chooses to use project revenue bonds rather than general obligation bonds to finance the project. For private ownership, the rate of return is influenced by the ratio of debt to equity of the company in the venture and by the rating of its bonds.

The effective property and income tax rates are significant factors in the capital charge for private ownership. Private owners may be able to take advantage of investment tax credits or property tax abatements unavailable to public owners, who on the other hand, pay no taxes. These tax advantages reduce the capital cost of resource recovery on a balance sheet basis, but do so by transferring part of the cost to the public treasury.

A combination of public financing and private ownership may be particularly attractive for resource recovery systems. It combines the low interest rates available through municipal financing with the tax deductions available to private firms. In this approach, a community may be able to issue pollution control revenue bonds and use the proceeds to help finance a private venture. The private firm then takes advantage of tax credits or other incentives to reduce its effective costs. However, the Internal Revenue Service (IRS) has been reluctant to allow such financing for resource recovery plants, since they do not process "valueless" wastes as required by IRS rules. (See chapter 7.)

Operating Costs

Operating costs include labor, maintenance, supplies, insurance, and utilities. Estimates of operating costs for various resource recovery technologies are shown in table 44. The labor component of average operating costs declines rapidly as the plant capacity increases; other components are more nearly proportional to capacity. Since operating costs are very sensitive to local wage rates and utility prices, the figures in table 44 should be considered as very rough estimates.

Total Costs of Resource Recovery Processing

Table 45 shows estimates of the total costs of resource recovery for plants of 1,000-tpd capacity. (Modular incinerator costs are shown for a 200-tpd plant.) These total cost estimates are based on average capital costs from table 43 (capital recovery factor = 0.1; capacity utilization factor = 0.70) and average operating costs from table 44.

Two points should be kept in mind when reviewing table 45. First, different technologies have different costs and produce different revenues. Second, the actual costs for any particular project may differ markedly from those shown.

Table 44.—Operating Costs of Centralized Resource Recovery (literature estimates and averages for 1,000-tpd plants)

			Operating cost' ($/ton)		
Technology	Reference	Year	Original year $	1979$	Average in 1979$
Waterwall incineration to steam	2	1975	$11.13	$13.36	$11.00
	18	1977	8.00	8.63	
Refuse-derived fuel with materials recovery	2	1975	6.36	7.63	8.90
	19	1977	9.33	10.07	
Refined refuse-derived fuel with materials recovery (ECOFUEL-ll@)	2	1975	8.69	10.43	10.40
Wet process refuse-derived fuel with materials recovery	2	1975	12.11	14.53	14.50
Gas pyrolysis					
• Purox™	2	1975	11.92	14.30	16.90
	20	_ 1977	18.00	19.42	
• Torrax®	2	1975	10.91	13.09	14.60
	21	1977	15.00	16.19	
Modular incineration with heat recovery	17	1977	9.91 10.14b	10.69-10.94	10.40
	22	1978	9.57C	9.57	

aLiterature estimates inflated t. 1979 dollars using implicit mice deflater. Averages–rounded to nearest 10 cents
b200-tpd plant.
c220-tpd plant.

Table 45.—Total Costs of Processing 1 Ton of MSW Using Various Resource Recovery Technologies (1,000.tpd plants in 1979 dollars)

	Estimated costs ($/ton)		
Technology	Capital'	Operating	TotalC
Waterwall incineration to steam	**$14.60**	**$11.00**	**$25.60**
Refuse-derived fuel with materials recovery	**6.50**	**8.90**	**15.40**
Refined refuse-derived fuel with materials recovery (ECOFUEL-11*)	11.60	10.40	22.00
Wet process refuse-derived fuel with materials recovery	6.70	14.50	21.20
Gas pyrolysis			
• Purox	15.00	16.90	31.90
. Torrax	14.60	14.60	29.20
Modular incineration with heat recoveryd	10.10	10.40	20.50

a Based on average investment from table 43. capital recovery factor 0.1. capacity utilization factor O 70
based on average operating costs from table 44.
c Actual cost of any particular project may differ markedly from these estimates
'200-tpd plant.

The figures in table 45 suggest that total processing costs for resource recovery plants range from $15 to $30 per ton of MSW. In general, the systems with higher processing costs produce higher valued products. Therefore, data such as that in table 45 cannot be used to select a system with lowest net cost.

In the next section it is shown that under average conditions, no system can produce sufficient revenues from recovered energy and materials to be economic without charging a substantial tipping fee. *

Figure C-2 of Working Paper No. 3 shows the MITRE Corporation's estimates of the dependence of total costs on plant size.(23) While more recent evidence suggests that MITRE has overstated the economies of scale,(14) it is nevertheless true that plant size is an important factor in total cost per ton. This suggests that in order to achieve lower processing costs, a number of communities might want to operate one large plant together rather than several small ones. However, these cost savings, if achievable, must be balanced against the increased cost of transportation to a central facility, the difficulty of locating an appropriate plant site, the challenge of finding a sufficiently large energy customer, and the costs of planning and operating a multi jurisdictional facility. The direct economics of this tradeoff are considered later in this chapter, and the institutional problems are discussed in chapter 7.

*A tipping fee is the charge, generally in $ per ton, for dumping waste at a landfill or a resource recovery plant.

Chapter 5 contains a discussion of the trade-offs between large- and small-scale plant concepts.

Materials and Energy Revenues From Various Resource Recovery Technologies

There is very little information on which to base estimates of potential revenues from most resource recovery technologies. Most of these estimates are speculative and do not represent actual marketing experience. Furthermore, revenues can be expected to depend on such local factors as the prices of alternative fuel supplies and the distance to markets. Prices for the recovered materials are known to vary widely over time. (In chapter 3, the marketability of various energy and materials products from resource recovery is discussed, and the impact of costs of transportation by rail is analyzed.)

Little information is available from which to determine whether the size of a facility affects product revenues per ton. Presumably, there would be economies of scale in marketing products, and larger amounts might bring higher net unit revenues. On the other hand, large customers would expect to share in these reduced marketing costs by paying lower average unit prices. Thus, the assumption is made in this analysis that revenues per ton of product are constant.

A resource recovery facility can reduce the weight of waste to be landfilled or otherwise disposed of by up to 80 or 90 percent, with equivalent reductions in the costs of such disposal. Typically, landfill or other disposal costs from $2 to $10 per ton. Thus, landfill costs may be reduced by $0.50 to as much as $9 per collected ton if resource recovery is used. (In this analysis, residue disposal fees are included in operating costs, so the full savings from avoiding landfill of $2 to $10 per ton are used.) Waste collectors may even be willing to pay a somewhat higher tipping fee to a resource recovery plant than to a landfill because they can save the lost time and the costs of repairing the damage to trucks that often occurs on rough landfill sites.

Table 46 recapitulates estimates of potential resource recovery revenues from table 11. These revenues have not been adjusted to account for the cost of transporting products to market. Such transportation charges could reduce them substantially, as noted in table 12. Revenues are included only for energy and ferrous metals, since aluminum, glass, and paper recovery technologies are still somewhat speculative. Recovery of both aluminum and glass might add $2 to $3 per ton of waste to revenues. (See table 11.)

The last column of table 46 shows estimates of minimum tipping fees for the various technologies. Here, the minimum tipping fee has been set equal to the net cost for waste disposal after credits are taken for energy and materials revenues. The tipping fee provides a basis for direct comparison with landfill costs since it is the price a resource recovery plant must charge to accept MSW from collectors. It is essentially the economic bottom-line for resource recovery. Table 46 also shows that centralized resource recovery is economically feasible today in areas where either the cost of transportation to distant disposal sites or the cost of landfill is high.

An indication of the plausibility of the estimates in table 46 can be gotten from examining actual tipping fees charged by the current generation of resource recovery plants. A compilation of tipping fees by the National Center for Resource Recovery (NCRR) shows that they are in the range of $5.60 to $16.00 per ton for plants now operating. Six of eight plants for which data are presented have tipping fees above $10 per ton.(24)

Table 46.—Estimated Revenues and Minimum Tipping Fees for Various Resource Recovery Technologies (1,000-tpd plants in 1979–all rounded to nearest whole dollar)

Technology	Total processing Costs[a] ($/ton)	Energy revenues[b] ($/ton)	Ferrous revenues[b] ($/ton)	Minimum tipping fee[c] ($/ton)
Waterwall incineration to steam.	$26	$9-17	—	$ 9-17
Refuse-derived fuel with materials recovery.	15	5-9	1-3	4-10
Refined refuse-derived fuel with materials recovery (ECOFUEL-11~).	22	9[d]	1-3	10-12
Wet process refuse-derived fuel with materials recovery	21	5-9	1-3	9-16
Gas pyrolysis				
• Purox	32	11	1-3	18-20
• Torrax ®	29	9-17	—	12-21
Modular incineration with heat recovery.	21	9-17	—	3-12

[a]Source Table 45
[b]Source Table 11
[c]Total costs minus revenues
[d]Assumed equal to highest RDF Price

Optimum Resource Recovery Systems

The design of an optimum resource recovery system for a region requires balancing a number of factors. These include: economies of scale in processing; costs of transportation; sales of recovered products; credits for avoiding landfill; costs and problems of multi jurisdictional planning and operation; and other less-tangible factors such as facility siting, delays in constructing large plants, and concentration versus dispersion of air and water emissions.

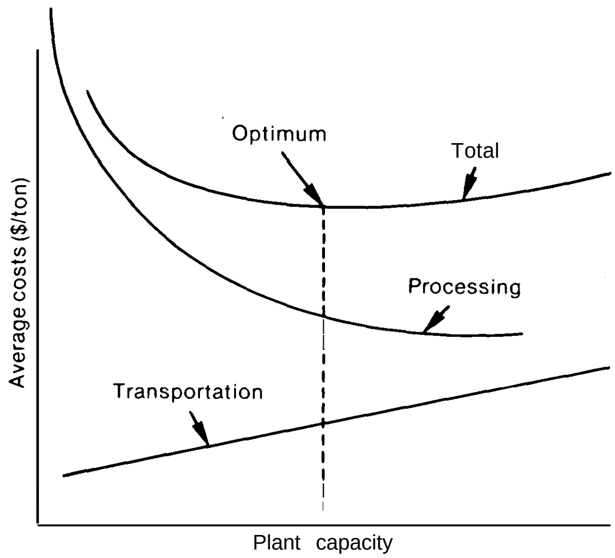
From an economic point of view, an optimum resource recovery system is the one that handles a region's wastes at lowest net cost per ton. (The net cost is the difference between processing and transportation costs on the one hand and product revenues on the other.) If unit revenue is independent of plant size, then the optimum system is the one for which the sum of processing and transportation costs is the smallest.

Figure 5 illustrates the determination of optimum plant size for a situation in which a single plant is to be designed to consume only part of an area's waste. As the plant capacity is made larger, the average processing cost per ton of MSW decreases, but at a decreasing rate. At the same time, average transportation costs per ton increase as waste must be hauled from further away. The result is that a minimum total cost is reached at a certain plant size. If the plant is made larger, economies of scale in processing are more than offset by increasing transportation costs, Similarly, transportation savings for a smaller than optimum plant are more than offset by the loss of economies of scale.

Some of the debate about resource recovery economics in recent years has been concerned with the optimum size for such plants. This, in turn, has centered on just how important the economies of scale are for larger sized plants. A perspective at one extreme is represented by the work done by MITRE Corporation for this study in 1976, reported as Working Paper No. 3.(6) By assuming that economies of scale persist for plants up to 10,000- tpd capacity, MITRE found optimum plants in the neighborhood of 4,000 to 10,000 tpd for two study regions (Eastern Massachusetts and "INOKY," see (6)).

At the other extreme, Black and Veatch, and Franklin Associates, in a study completed in 1978, found that economies of scale in processing were exhausted at 1,000- to 1,500)-tpd capacity for all technologies, with

Figure 5.—Optimum Resource Recovery Plant Capacity



SOURCE Off Ice of Technology Assessment

the possible exception of Purox®. In fact, they found that for the Kansas City region 200-tpd modular incinerators and 1,000-tpd waterwall incinerators have the lowest net costs and are roughly equal in economic performance.

In view of the more recent findings that economies of scale in processing are exhausted above 1,000- to 1,500-tpd capacity, plants of this size are likely to be the largest that are economically optimum. Since a l,000o-tpd plant can dispose of the MSW generated by about half-a-million people, plants that would serve regions with a population of 1 million or higher are unlikely to be of interest in the near future.

Subsidies for Costs of Resource Recovery

Rationale

Subsidies might be offered for resource recovery activities for two purposes. One is to offset high tipping fees (illustrated in table 46) in areas in which it is desired to implement resource recovery and where the resource recovery tipping fee exceeds the cost of landfill. The other is to overcome the risks faced by operators who are unwilling to invest in new resource recovery techniques in view of their uncertain technology and economics. (These two purposes are explained more fully in chapter 7.) This chapter considers the implications and the costs of various subsidies used for the first purpose. The second purpose is discussed in chapter 7.

Magnitudes of Subsidies

Table 46 suggests that the net cost of resource recovery can range from $3 to $20 per ton, with an average of about $10 per ton for systems under serious consideration. With landfill costs in the range of $2 to $10 per ton, a subsidy ranging from $1 to $18 per ton would be necessary to make resource recovery generally competitive.

The costs and implications of a national subsidy of $8 per ton are examined here as a reasonable proposal for a uniform national program. What might a subsidy of $8 per ton of MSW cost on a national basis, and how would it translate to capital or operating subsidies? For the 136 million tons of MSW collected each year, an $8 per ton subsidy is equivalent to approximately $1 billion per year.

Put another way, as can be seen from table 45, $8 per ton is equivalent to a capital subsidy of one-half to more than all of the capital cost of resource recovery. It is also equivalent to about one-half to nearly all of the operating costs of a plant.

Proposals have been made to devise an operating subsidy that would be proportional to the energy or materials revenues. For example, a subsidy of $8 per ton of MSW could be pegged to the ferrous scrap revenues, which would typically be $1.00 to $2.80 per ton of waste processed. Assuming that 140 pounds of ferrous scrap were recovered per ton of MSW (see table 8), a subsidy of $8 per ton of MSW is equivalent to a subsidy of $114 per ton of ferrous scrap. This is a very large subsidy in comparison to typical prices of $20 to $40 per ton for such ferrous scrap.

Alternatively, an operating subsidy could be pegged to energy revenues. Since MSW typically contains about 9 million Btu per ton as fuel value, a subsidy of $8 per ton is equivalent to a subsidy of approximately $1 per million Btu, over and above a market price for the recovered energy. This, too, is a large subsidy in comparison to current wholesale energy prices of $1 to $4 per million Btu.

Discussion of Subsidies

The rough estimates presented above suggest that on a national average basis subsidies for resource recovery are not justified by the value of the potentially recoverable materials and energy; the subsidy required is simply too large in comparison to the value of the recovered resources. Thus, a Federal program to subsidize resource recovery from MSW for the entire Nation is not justifiable on resource supply grounds.

Three other perspectives may justify a limited subsidy for resource recovery, however. First, if environmental costs of existing disposal methods (landfill, ocean dumping) exceed $8 per ton of MSW, then a subsidy of $8 per ton might be justified if it were the only way to avoid those costs. Second, resource recovery may be much more nearly economic now in certain locations than the national average. In this case, subsidies much lower than $8 per ton might be adequate to stimulate its adoption. These are largely local or State circumstances for which Federal subsidy can be justified only on the grounds that those who generate MSW cannot afford to dispose of it properly. Third, subsidies can also be used to overcome the technical and economic risks of a new technology, as discussed in chapter 7. Federal subsidy limited to a few plants is justified to help develop technology that may subsequently become economically feasible in many other locations.

The Interactions of Centralized Resource Recovery With Beverage Container Deposit Legislation and With Source Separation

A source separation program or beverage container deposit legislation (BCDL) could change the composition of MSW and reduce the amount available for resource recovery. This could make an existing plant less economical to operate or require an existing plant to reach out to a larger service area. For the same reason, a smaller plant could be constructed if it were designed with these programs in mind. This section analyzes the interactions of such programs. (See chapter 4 for details of source separation approaches and chapter 9 for BCDL.)

Beverage Container Deposit Legislation

BCDL, if successful, would remove some aluminum, glass, and steel from the waste stream. But none of the other waste components would be affected. The effect of removing these materials on resource recovery revenues is an important question.

In chapter 9, five scenarios are presented for the impact of BCDL on the composition and amount of MSW, had BCDL been fully effective in 1975. Various assumptions are made about beverage market shares by container type and about return and recycle rates for containers. These scenarios include the actual 1975 situation (scenario I) and four projections, ranging from an all-glass refillable situation to a situation with a high can market share. Table 47 shows the composition and the total amount of MSW for each scenario.

The example developed in chapter 4 to illustrate the interaction of resource recovery and source separation can be used to show how BCDL might affect resource recovery revenues under the estimates of changes in waste composition for the five scenarios.

Table 47.—Composition of MSW Under Five Beverage Container Deposit Scenarios for 1975’

	Composition (o/o by weight)				
	Scenario				
Component	I	II	III	Iv	v
Ferrous metal	8.3	7.4	7.6	7.9	7.6
Glass	10.0	10.3	8.1	6.8	9.0
Aluminum	0.70	0.37	0.38	0.49	0.47
RDF	72.5	73.4	75.2	76.0	74.4
Total waste load b (tons/day).	875	865	844	835	853

a see chapter 9 for definition of five scenarios
b waste load for a cit, of 500,000 people, reflecting material removal by BCDL
SOURCE Off Ice of Technology Assessment

That example concerns a city of 500,000 people, each of which generates an average of 3.5 pounds per day of MSW with a national average composition. To serve this community without deposit legislation, a resource recovery plant of 875-tpd average capacity would be needed. (With a capacity utilization factor of 80 percent, the plant would have to be rated at 1,100 tpd.) In each scenario, the plant is assumed to produce RDF and to recover ferrous metals, aluminum, and glass. It is assumed that an optimal resource recovery plant is built for each scenario.

Table 48 summarizes the results of the analysis of resource recovery revenues and credits under the five scenarios. Without BCDL, daily average revenues and credits are $15.73 per ton. * Under the four scenarios, revenues and credits are in the range of $15.20 to $15.72 per ton. Thus, for plants whose design takes into account the removal of materials by BCDL only small changes are anticipated in revenue per ton.

If BCDL were implemented after the resource recovery plant were built, revenue would decline from $15.73 to a range of $14.89 to $15.08 per ton of original capacity; i.e., the decline would be in the range of $0.65 to $0.84 per ton of waste processed. Even in the worst case, however, (scenario III) total resource recovery revenues would decline by only $727 per day or by about 5 percent.

*Estimates of revenue and credits cannot be calculated so that they are accurate to four or five significant figures as shown here. In this analysis the extra figures are carried solely for the purpose of indicating small differences from a base line case.

Table 48.—impact of Beverage Container Deposit Legislation on Potential Resource Recovery Revenues and Credits for Five Scenarios in 1975

	Revenue or credita ($/day)				
	Scenario				
Component of revenue	I	II	III	Iv	v
Ferrous metal	1,788	1,595	1,595	1,623	1,595
Glass	660	675	510	420	570
Aluminum	930	480	480	600	600
Total materials revenues	3,378	2,750	2,585	2,643	2,765
Energy revenues. . . .	5,906	5,906	5,906	5,906	5,906
Landfill credits b for RR.	4,476	4,434	4,368	4,338	4,392
Landfill credits b for BCDLC	—	60	174	240	132
Total revenues and credits.	13,760	13,150	13,033	13,127	13,195
Credits and revenues ($/ton).	15.73	15.20	15.44	15.72	15.47
Credits and revenues for original capacity ($/ton).	15.73	15.03	14.89	15.00	15.08

a unit revenues and credits are averages of values in table 11
b At a tipping fee of $6 Per ton
c Reflects removal of material from waste stream by BCDL

The estimated revenue changes presented here are intended to serve only as approximate indicators of the probable impact of BCDL on resource recovery revenues and credits. They are sensitive to the assumed efficiency of materials recovery, to recovered product prices, to the change in waste composition, and to the assumption that the same kind of plant is used in each case. Nevertheless, it can be concluded from this analysis that BCDL would have only a small impact on resource recovery economics. This is true largely because the material revenues are a relatively small fraction of total revenues and credits, and because they are not markedly affected by removal of a portion of the container wastes by BCDL.

It is noteworthy that most of the revenue loss under BCDL is from aluminum and glass. However, technologies for recovery of these materials are still in the developmental stage, and they may not be able to produce any revenues at all in the open market. (See chapters 3 and 5.) If a mass burning process such as waterwall incineration is used, materials are not usually recovered at all. In both of these cases, metals and glass would be a drag on the performance of resource recovery and would increase the fee for ash disposal. Their removal by BCDL would be an operational advantage.

Source Separation

Chapter 4 contains an analysis of the economic interaction of source separation and centralized resource recovery similar to the one presented above for BCDL. The major findings of the analysis are: a) if source separation and centralized resource recovery are planned and implemented together, the economics of the combination are equal to or better than those of either option alone; and b) if source separation is implemented after an optimal resource recovery plant is built and the plant cannot expand its service territory to make up the decrease in waste load, its economic performance would be seriously hurt.

Findings on the Economics of Centralized Resource Recovery

This chapter discusses the costs and benefits of centralized resource recovery, with a focus on the direct costs and revenues of such systems as seen by the owner, operator, or investor. Data from a number of sources are compiled and summarized to provide estimates of capital and operating costs, and of revenues for several technologies of interest. Many factors specific for a given project can influence these numbers. The reader, therefore, is cautioned that these estimates cannot be used to plan, design, or evaluate any particular project proposal.

Processing MSW in centralized resource recovery plants to recover energy and materials has been estimated to cost between $15 and $32 per ton of waste depending on the technology used. Revenues from the sale of energy and materials can range from $5 to $17 per ton of waste, with more costly systems generally producing greater revenues. Net costs, equivalent to the minimum tipping fees, are expected to range from $3 to $21 per ton. (A range of $6 to $16 per ton is typical of tipping fees at plants currently in operation.)

Larger plants may be able to charge somewhat lower tipping fees, although economies of scale seem to largely disappear above 1,000 to 1,500 tpd. Small-scale modular incinerators can apparently charge tipping fees in the range of $3 to $12 per ton at a 200-tpd size.

All of these costs and revenues are based on very limited commercial experience, or in some cases only on engineering designs. Thus, they contain a high degree of uncertainty. Additional experience is, therefore, necessary before reliable conclusions about them can be drawn. However, in areas of high landfill costs or where lack of landfill space causes high costs for transportation to distant landfill sites, centralized resource recovery can be economically feasible today.

The optimal design of a centralized resource recovery plant, or a system of several plants, represents a tradeoff among three factors: 1) processing costs per ton, which decrease as plant size increases; 2) transportation costs per ton from collection points, which increase as plant size and haul distances increase; and 3) energy and materials revenues, the energy portion of which are site-dependent. For each service area, there is a lowest cost mix of plant sites and sizes that is determined largely by the tradeoff between the cost of transportation and the economies of scale in processing costs. The best available current information suggests that plants in the 1,000- to 1,500-tpd” range may be the largest economically optimum sizes for most locations.

Subsidizing the capital or operating costs of centralized resource recovery nationwide cannot be justified on the basis of the value of the recovered energy or materials. For example, a subsidy of $8 per ton, which is designed to make an average $14 per ton resource recovery tipping fee competitive with an average $6 per ton landfill fee is equivalent to a subsidy for recovered ferrous metal of several times its market price or to a subsidy for recovered energy of nearly $1 per million Btu (about $5 per barrel of oil equivalent). There is no a priori reason to subsidize resource recovery if sound alternative disposal methods, such as landfill with adequate environmental controls, are available at lower cost.

Resource recovery does not generally need a Federal subsidy if the revenues from recovered energy and materials plus landfill credits exceed its costs. A subsidy may be economically justified, however, in three specific circumstances: 1) if the environmental or health costs of alternative disposal methods such as landfill or ocean dumping exceed the subsidy, and it is not feasible to reduce those costs through regulation and control; 2) if the spread between the resource recovery and the landfill tipping fees is considerably less than $8 per ton, and a subsidy is justified by a desirable but non-monetary benefit of energy recovery such as reduced oil imports; 3) when used for a small number of demonstration plants to compensate communities for bearing the risks associated with trying an uncertain new technology on behalf of the rest of the Nation. Federal subsidy for the first two purposes can be justified economically only if local areas cannot afford proper disposal of the wastes they generate. Federal subsidy for the third purpose is reasonable from an economic point of view.

Beverage container deposit legislation might reduce the revenue of an existing resource recovery plant by 5 percent at most. There would be no revenue reduction if the recovery of aluminum and glass do not become technically and economically feasible. Systems, such as waterwall incineration, which do not recover materials, will not suffer a loss in revenues. Thus, there is no serious conflict between resource recovery and beverage container deposits.

Source separation would resource recovery plant revenues from both materials and energy. A comprehensive source separation program could seriously reduce the revenues from an existing resource recovery plant. However, effective source separation implemented either before or when a centralized facility is planned would allow a smaller resource recovery plant to be built. A combination of resource recovery and source separation may be more effective economically than either program alone. It may be the ideal approach for some communities.

References

1. Engineering News Record, various issues.
2. Schulz, Helmut W., et al., Resource Recovery Technology *for* Urban *Decision*-makers. Prepared for the National Science Foundation by the Urban Technology Center, Columbia University, January 1976, p. 14.
3. Ralph M. Parsons Company, Engineering and Economic Analysis *of* Waste to Energy Systems, prepared for Industrial Environmental Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio, Report no. EPA-600/7-78-086, May 1978, p. 251.
4. Gordian Associates Incorporated, Overcoming Institutional Barriers to *Solid* Waste Utilization as an Energy Source: *Final* Report. Report to the U.S. Department of Energy, HCP/L-50172-01, November 1977, p. 39.
5. Black and Veatch, and Franklin Associates, Lt'd, Detailed Technical and Economic Analysis *of* Selected Resource Recovery Systems. Report to the Mid-America Regional Council, Kansas City, Me., 1978, p. 3.
6. The MITRE Corporation, Evaluation *of Policy Issues* in Resource Recovery: An Application *of* Recovery and Market *Plan*ning (RAMP), published as Working Paper no. 3 in vol. II of this report, July 1978.
7. Schultz, Helmut W., et al., op. cit., p. 246.
8. Gordian Associates Incorporated, op. cit., p. 67.
9. National Center for Resource Recovery Inc., New Orleans Resource Recovery Facility Implementation Study, Washington, D. C., September 1977.
10. Ralph M. Parsons Company, op. cit., p. 252.
11. Gordian Associates Incorporated, op. cit., p. 100.
12. Auburn Solid Waste Review Committee, Auburn *Solid* Waste to Energy Project Proposal Evaluation, Auburn, Maine, July 1978, p. 68.
13. The MITRE Corporation, op. cit., p. 512.
14. Gordian Associates Incorporated, op. cit.
15. Black and Veatch, and Franklin Associates, Lt'd., op. cit.
16. Ross Hofmann Associates, Evaluation *of Small* Modular Incinerators in Municipal Plants. Prepared for the U.S. Environmental Protection Agency under contract no. 68-01-3171, EPA Publication SW-1 13c, 1976.
17. Black and Veatch, and Franklin Associates, Lt'd., op. cit., p. 6.
18. Ibid., p. 15.
19. Ibid., p. 21.
20. Ibid., p. 32.
21. Ibid., p. 26.
22. Auburn Solid Waste Review Committee, op. cit., p. 66.
23. The MITRE Corporation, op. cit., p. 515
24. "Resource Recovery Activities, " *NCRR Bulletin: The* Journal *of* Resource Recovery, 9:1, March 1979, p. 18.