Materials and Energy From Municipal Waste

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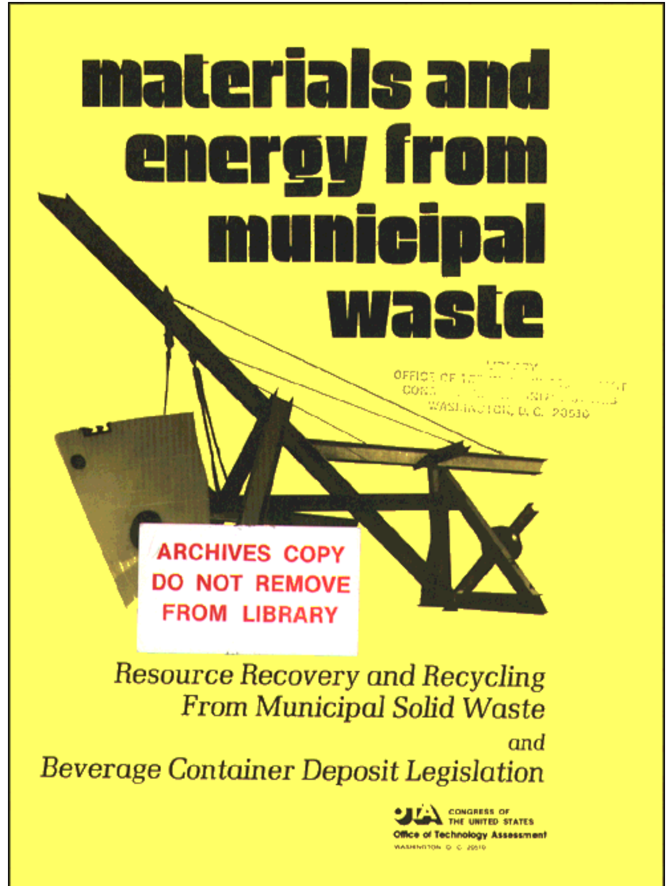

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Foreword

The United States annually generates more than 135 million tons of municipal solid waste (MSW). Its disposal is a rapidly growing problem for many areas of the country, where such traditional methods as open dumping, landfill, uncontrolled incineration, and ocean burial are too expensive or environmentally unacceptable. At the same time, MSW contains over two-thirds of the national consumption of paper and glass, over one-fifth of the aluminum, and nearly one-eighth of the iron and steel, If burned, the combustible portion of MSW would be equivalent to about 1.9 percent of the Nation's annual energy use.

Resource recovery and recycling materials and energy from MSW can play significant roles in helping to solve waste generation and disposal problems. In addition, resource recovery, recycling, and reuse can contribute to the wise and efficient use of materials, to conserving materials and energy, to preserving the environment, and to improving the balance of trade by reducing our dependence on imported natural resources,

This report addresses important questions that have arisen about the feasibility of various approaches to resource recovery, recycling, and reuse. It presents the results of an examination of important technological, economic, and institutional factors. Federal incentives and other policies that might stimulate resource recovery, recycling, and reuse are identified and their effectiveness and impacts are assessed.

The study was requested by the Technology Assessment Board on behalf of the House Committee on Science and Technology and the Senate Committee on Commerce, Science, and Transportation. We hope that these committees, and others including the House Committee on Interstate and Foreign Commerce and the Senate Committee on Environment and Public Works, will find this report helpful as they confront the continuing problems and opportunities of solid waste management. resource recovery, recycling, energy supply and conservation. and product reuse.

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Director

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Executive Summary

The Problems and the Opportunities

The United States annually generates more than 135 million tons of municipal solid waste (MSW). Its disposal is a rapidly growing problem for many areas of the country, where such traditional methods as open dumping, landfill, uncontrolled incineration, and ocean burial are too expensive or environmentally unacceptable. At the same time, MSW contains over two-thirds of the national consumption of paper and glass, over one-fifth of the aluminum, and nearly one-eighth of the iron and steel. If burned, the combustible portion of this waste would be equivalent to about 1.9 percent of the Nation's annual energy use.

Resource recovery and recycling materials and energy from MSW can play significant roles in helping to solve waste generation and disposal problems. In addition, resource recovery, recycling, and reuse can contribute to the wise and efficient use of materials, to conserving energy, to preserving the environment, and to improving the balance of trade by reducing our dependence on imported natural resources. By using materials more than once, virgin resources can be conserved for ourselves and for future generations.

This report addresses important questions that have arisen about the feasibility of various approaches to resource recovery, recycling, and reuse. It presents the results of an examination of influential technological, economic, and institutional factors, Federal policies that might stimulate resource recovery, recycling, and reuse were identified and their effectiveness and impacts were assessed, The criteria used for assessing the policy options include technical and administrative feasibility (effectiveness), economic efficiency, equity, security, and diversity.

Only those problems and opportunities associated with the disposal of ordinary MSW in the United States have been studied. The management of hazardous wastes, sewage sludges, and other special wastes; remanufacturing, reworking, or refurbishing products for reuse; recycling industrial scrap; and recovering materials or energy from agricultural, forestry, mining, or industrial residues, have all been specifically excluded.

The Current Federal Role in the Management of MSW

Direct Federal involvement in solid waste disposal, resource recovery, recycling, and reuse has evolved through three major Acts:

- The Solid Waste Disposal Act of 1965,
- The Resource Recovery Act of 1970, and
- The Resource Conservation and Recovery Act of 1976 (RCRA),

All of these Acts have been motivated by a concern for the public health and the environmental impacts of improper disposal, by the rising costs of disposal by traditional means, and by the recognition that municipal wastes contain valuable materials and energy. Each emphasizes that the primary responsibility for municipal waste collection and disposal rests at the local level. All have provided for Federal roles in research, development, and demonstration: technical assistance; information dissemination; and grants to State and local governments for planning for solid waste management. RCRA makes such grants conditional on the adoption by a State of a series of programs designed to upgrade land disposal and facilitate resource recovery. It also provides for the Federal procurement of recycled materials and for Federal involvement in developing performance standards for recovered materials and energy in order to assist in developing markets for them.

While reaffirming limited Federal involvement in resource recovery and recycling, RCRA has recognized the possibility of future Federal policy initiatives by creating the Cabinet-level interagency Resource Conservation Committee to examine continuing resource conservation issues.

The Federal Government has played a less direct, although significant role, in influencing the supply and demand for recovered materials and energy through policies on air and water pollution control, railroad rate regulation, materials taxation, control of ocean waste disposal, and use of public lands.

Issues and Findings

The findings of this study are summarized in the following pages, grouped under five major issue areas:

I. Methods for resource recovery (p. 5).
II. The marketability of recovered resources (p. 9).
III. Institutional barriers to resource recovery and recycling (p. 12).
N. Incentives for resource recovery and recycling (p. 14).
v. Beverage container deposit legislation (p. 16).

Issue Area I

Methods for Resource Recovery

Materials may be recovered from MSW for recycling in two ways: by collecting wastes that have been kept separate as they are generated ("source separation"), and by separating mixed wastes in a central facility ("centralized resource recovery"). Energy is saved using either method, since less energy is used in manufacturing products from recovered materials than from virgin raw materials. In addition, with centralized resource recovery energy can be recovered as fuel from the organic components of MSW.

A number of technologies for centralized resource recovery have been brought to various stages of development. Each has different technical and economic performance characteristics. Source separation, which is designed to recover specific components of the waste stream, can be organized in several ways. This report describes both of these methods and assesses their status and capabilities.

1 What is the status of source separation in the United States?

Source separation for the recovery of recyclable materials from MSW is widely practiced in the United States today. It is the only available method with which wastepaper can be recovered for recycling into new paper products. It is also used to recover glass, ferrous and nonferrous metals, and yard waste. Nearly all of the MSW now recovered for recycling is collected in source separation programs.

The types of source separation programs currently operated by municipalities, industry, and volunteer groups include curbside separate collection programs, multimaterial recovery in community recycling centers, industry-sponsored recycling programs, and commercial and industrial methods of source separation. According to the Environmental Protection Agency, about 133 communities were collecting newspapers in curbside programs in May 1978. Another 40 were collecting other kinds of paper and/or glass and cans. Industry-sponsored programs collected 25 percent of all aluminum beverage cans produced in 1977.

Source separation has grown in popularity in the last decade. However, some programs have experienced technical or organizational problems, many others have failed owing to problems in marketing their products, and still others have faced indifference or hostility from proponents of alternative approaches. Nevertheless, a great deal of expertise has been developed for designing and operating such programs. Much of the curbside collection activity has taken place in small towns and moderate-sized cities. A residential source separation program encompassing a major urban area has yet to be demonstrated. (Chapter 4)

2 How effective is source separation?

The success of source separation programs depends on obtaining and maintaining a high degree of cooperation and participation on the part of those who generate the waste. Source separation can produce sizable revenues and energy savings from MSW, but has only a limited effect on the total solid waste stream. For example, at 50-percent participation, a comprehensive residential and commercial program could recover around one-fourth of a community's MSW and earn revenues of $5 to $12 per ton of waste generated. But, three-fourths of the MSW would remain for recovery or disposal by other means. With such a program in place, a community would still have ample opportunity to install a centralized system to recover materials and/or energy. (Chapter 4)

3 Would source separation in a community detract from efforts to recover energy and materials in a centralized facilit y?

Source separation removes some MSW components that a centralized resource recovery plant would rely on for fuel and, depending on its design, for recoverable materials. Consequently, it has the potential to reduce the revenues of an existing resource recovery facility. For this reason, capital-intensive, centralized systems should be designed to accommodate existing or future separate collection programs, thus reducing the possibility of revenue problems. Depending on the level of participation and on market conditions, a carefully planned combination of source separation and centralized resource recovery may be the optimal approach from an economic point of view. (Chapters 4 and 6)

4 How should Federal policy toward resource recovery and recycling treat source separation?

Nearly every potential Federal action discussed below, which encourages resource recovery or recycling, would stimulate source separation activities unless specific barriers to it are raised. Therefore, Federal programs, including assistance to State and local governments for solid waste planning, should be designed to incorporate source separation as a local option.

Federal efforts to assist source separation activities could include funding for research on collection systems, for innovative program design, and for improving equipment used in intermediate processing to upgrade collected materials for recycling. Federal assistance is needed to implement and maintain a demonstration program for curbside source separation in a large city. If such a program were successful, other major urban areas would be shown what could be done and how to do it. (Chapter 4)

5 What is the status of technologies for centralized resource recovery for energy and materials?

A number of technologies for burning the combustible portion of MSW or for converting it to solid, liquid, or gaseous fuels are at various stages of development. Techniques have also been developed, with differing success, for recovery of ferrous and nonferrous metals, aluminum, glass, and paper fiber.

The only commercially operational methods for recovering energy are waterwall combustion and small-scale modular incineration to produce steam, and the production of refuse-derived fuel (RDF) by wet and dry processes. The only commercially operational technologies for recovering materials from mixed MSW are the magnetic recovery of ferrous metals, the recovery of low-grade fiber by wet separation, and the production of compost by natural processes. Aluminum and glass recovery are being actively developed as is energy recovery by both anaerobic digestion and pyrolysis. (Chapter !5)

6 How much does centralized resource recovery cost?

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. Most of the revenues come from the sale of energy.

Because revenues are generally insufficient to cover the costs of centralized resource recovery, plants must charge a price for waste disposal to make up the difference. This charge is commonly called a “tipping fee. ” For technologies now being considered, including small-scale modular incinerators, tipping fees are estimated to range from $3 to $21 per ton for plants able to process 1,000 tons of MSW per day. (Tipping fees at existing commercial plants range from $6 to $16 per ton.) Tipping fees for waste disposal at landfills typically range from $2 to $10 per ton nationwide. Therefore, in many parts of the country landfill is still the most economical way to dispose of waste. Consequently, resource recovery has the greatest potential where both landfill costs and energy prices are high, such as in the urban Northeast. [Chapter 6)

7 What is the energy potential of centralized resource recovery?

Energy can be recovered by centralized resource recovery either as fuel or as heat and also as the energy savings that accrue from recycling materials. As an upper limit, the total recovery of all the energy in MSW would be equivalent to about 1.9 percent of the Nation's current annual energy consumption. Recycling all of the iron and steel, aluminum, copper, and glass could save about 0.4 percent more for an upper limit on total savings of the equivalent of 2.3 percent of current energy use. Thus, centralized resource recovery could play a small, but not insignificant role in conserving energy. Technical, economic, and institutional factors, however, will keep the amount of energy saved by resource recovery in the foreseeable future to a fraction of its potential. (Chapter 5)

8 Are there environmental problems with centralized resource recovery?

Relatively little is known about the effluents from operating centralized resource recovery plants or about the nature and degree of workplace hazards they may present. This is largely because there has been little opportunity to gather data, and because there is considerable variability in and ignorance about the composition of both MSW and the recovered products. A number of studies currently underway should produce information about air and water emissions, bacteria and viruses in the plant environment, and toxic substances in all media including solid residuals. Authority exists for regulating these workplace and environmental problems, if needed. Should activity in centralized resource recovery continue, it will be desirable to step up research and to promulgate regulations needed to control any potentially harmful side effects. (Chapter 5)

9 How large should centralized resource recovery plants be?

The optimal design of a centralized resource recovery pIant, 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. This is determined largely by the tradeoff between the cost of transportation and the economies of scale in processing costs. Early enthusiasm for very large plants capable of processing 3,000 to 6,000 tons of MSW per day has diminished as such facilities have encountered difficult institutional problems. Moreover, the best available current information suggests that plants in the 1,000-to 1,5000-tpd range maybe the largest economically optimum sizes for most locations. In some communities plants as small as 50 to 200 tpd may prove to be the most satisfactory. (Chapters 5 and 6)

10 How does the nature of energy markets affect the best plant size for centralized resource recovery?

Only electric powerplants, large factories, or large complexes of office buildings can consume all the energy output of a l,000-tpd resource recovery facility. These types of potential customers have proven difficult to reach by proposed resource recovery projects. Electric utilities, which were once seen as major potential users of energy from MSW, have been less than enthusiastic. This is largely because using refuse-derived energy presents certain technical difficulties and also because current approaches to rate regulation offer no incentive to try it. Furthermore, in a given service area, MSW can provide only a few percent of the fuel needs of an electric utility. Thus, utilities have been reluctant to contend with the numerous technical and institutional problems just to obtain a minor part of their total fuel needs.

On the other hand, there area large number of potential customers such as office buildings, institutions, and factories for smaller quantities of refuse-derived energy. Smaller resource recovery plants in the 25-to 600-tpd range might adequately serve their energy needs. Furthermore, some of the problems that arise when several communities attempt to regionalize in order to build large plants would thus be avoided. Smaller resource recovery plants, which are more common in Europe, might feature direct incineration to produce steamer hot water and forego materials recovery altogether. They might also permit a more flexible approach by making it possible for a community or region to adopt resource recovery gradually rather than all at once.

However, not enough is known about the environmental and workplace health implications of operating a network of small plants scattered throughout a region. Also, more needs to be known about the energy demand characteristics of potential industrial, commercial, and institutional customers, in order to learn whether they can indeed become major consumers of energy from waste. (Chapters 5 and 6)

11 How can the Federal Government most effectively fund additional research on centralized resource recovery technologies?

Over the past 15 years, there have been a number of federally funded research, development, and demonstration projects concerned with centralized resource recovery. There has also been vigorous activity in the private sector. The Federal R&D presence would be most effective in identifying, evaluating, and controlling environmental and occupational problems; in characterizing materials; in funding basic studies of processes for size reduction, materials separation, combustion, and chemical reaction; and in exploratory design—particularly of small-scale systems for processing and using recovered materials and energy. The remaining technical problems can probably be solved most effectively by private firms in the course of commercial development. (Chapter 5)

Issue Area II

The Marketability of Recovered Resources

Substantial amounts of various materials and types of energy can be recovered from MSW today using either centralized separation and recovery or source separation. The quantities of recoverable resources will continue to grow in the future as materials use grows, barring major Government action or other events that would restrict the production and use of materials generally. Such recovered resources compete both with virgin materials and energy, and with secondary materials from other sources. Thus, in order to ascertain whether resource recovery can be widely implemented, it is necessary to examine factors that affect the marketability of recovered materials and energy. These include their prices and qualities, the influence of transportation costs, and the role of Federal policy.

12 Would materials and energy recovered from MSW be marketable?

Productive uses can be made of recovered iron and steel, aluminum, paper, glass, and energy with existing technologies and in existing facilities. Potential markets exceed any anticipated level of recovery today and through 1995 for iron and steel, aluminum, and paper. Glass markets are developing rapidly as the technical feasibility and economic, environmental, and energy advantages of producing containers from waste glass become evident. Energy markets far exceed the potential level of recovery from MSW nationwide. However, the prices that users are willing to pay and the product quality they demand could be barriers to the profitable sale of large amounts of recovered resources, if resource recovery were widely adopted. Furthermore, certain forms of energy including RDF, steam, and low-Btu gas must be produced near their customers if transportation costs are to remain acceptable. (Chapter 3)

13 Would recovered resources from MSW disrupt existing markets for secondary materials and energy?

At any foreseeable level, resources recovered from MSW would be unlikely to affect existing markets for secondary, or scrap, iron and steel. High levels of additional aluminum and paper recovery would add substantially to the current trade and could be disruptive. Since current trade in scrap glass is quite limited, glass recovery essentially represents creation of an entirely new market rather than disruption of an existing one. In view of the current energy situation and the relatively small amounts of energy recoverable from MSW, recovered energy would not pose a threat to established energy markets. (Chapter 3)

14 What prices can be expected for recovered materials and energy?

Typical prices for recovered materials and energy are shown in table 1. Since there has been little or no commercial trade in some of these commodities, the prices are somewhat speculative. They are based on the judgments of informed observers. Prices for recovered ferrous metal, aluminum, and paper are likely to fluctuate widely over time as do the prices for these materials today. (Chapter 3)

15 Would a Federal stockpile stabilize markets for recovered materials?

Established markets for secondary iron and steel, aluminum, and paper exhibit wide variations over time in both prices and quantities traded. The prices both for postconsumer aluminum cans and for newspaper obtained through separate collection programs have been more stable because primary aluminum companies have been offering stable prices to recyclers and because there are established long-term contracts for delivering waste

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Table 1.—Typical Prices and Gross Revenues for Recovered Resources Delivered to Market

Resource type	Delivered price[a]		Potential gross revenue[b] ($/ton of MSW)
From centralized resource recovery			
Iron and steel	15-40	$/ton	1.05-2.80
Glass	10-20	$/ton	0.48-0.96
Aluminum	300	$/ton	1.20
Other nonferrous metal	100-200	$/ton	0.10-0.20
Dry fuel (RDF)	0.50-1.00	$/million Btu	4.50-9.00
Steam	1.50-3.00	$/1,000 lb	8.55-17.10
Medium-Btu gas	[illegible]	$/million Btu	9.00-18.00
Electricity[c]	1.5-3.5	¢/kWh	6.00-14.00
From source separation			
Newspaper	20-45	$/ton	0.66-1.46
Books and magazines	5-20	$/ton	0.06-0.23
Corrugated paper	15-45	$/ton	0.70-2.07
Office paper	75-120	$/ton	1.43-2.28
Steel containers	20-40	$/ton	0.40-0.80
Glass containers[d]	20-30	$/ton	0.92-1.38
Aluminum containers	300	$/ton	0.80

[a]Source: OTA estimates from various industry sources.
[b]Based on typical amounts recoverable. Must be reduced to account for freight costs.
[c]Wholesale prices.
[d]Color sorted.

newspaper to recycled newsprint mills. Current trade in waste glass is small but growing rapidly, with relatively stable prices. A brief anaysis of a Federal stockpile for recovered resources suggests that this would be an ineffective, unnecessary, or overly expensive mechanism for stabilizing markets for materials recovered from MSW. (Chapter 3)

16 Can Federal procurement policy improve markets for recovered materials?

Federal procurement policy can strengthen markets for recovered materials by emphasizing their use and by eliminating arbitrary barriers to them. Existing General Services Administration regulations under RCRA, if followed, represent a useful move in this direction. (Chapter 3)

17 Is Federal support for R&D on the uses of recovered materials adequate?

Federal R&D support on the uses of recovered resources, as opposed to their production, is limited. Such research might find new uses and improve old ones, and is easily justifiable on economic grounds. Under RCRA, only the Department of Commerce has authority for such support, and that authority has not been funded. The Bureau of Mines has done limited work in this area under its basic authority. Additional Federal support for R&D on the uses of recovered resources appears to be desirable. (Chapter 3)

18 Is additional Federal action needed to support the development of specifications for recovered resources?

Specifications for the quality of recovered resources are needed mainly to facilitate trade. They are not required for the purpose of protecting consumers because few recovered resources reach consumers without further industrial processing. (Important exceptions are flammability standards for cellulosic insulation, recently established on an emergency basis by an Act of Congress, and health and safety standards for reusable beverage containers.)

Existing specifications promulgated by the secondary materials industries and based on the origin of secondary materials appear to be adequate to support trade in separately collected iron and steel, aluminum, and paper. Separately collected glass is currently traded under quality/price negotiations for each shipment. Composition specifications to facilitate trade in materials and energy from centralized resource recovery plants are currently in the final stages of development by a committee of the American Society for Testing and Materials. In view of the current state of activities concerned with voluntary standards there seems to be no need for Government action beyond that authorized under RCRA. However, funds appropriated for this purpose have not been adequate. (Chapter 3)

19 How significant are transportation costs in the economics of resource recovery?

Freight rates for transporting recovered materials and certain forms of recovered energy to markets can seriously impair the economics of resource recovery. For example, for shipments by rail in the 200- to 400-mile range, railroad freight rates can range as high as 25 to 80 percent of the gross income from the sale of waste iron and steel, paper, and RDF. Even a 50-percent reduction of freight rates for these resources would still leave freight charges a substantial cost factor. (Chapter 3)

20 Do railroad freight rates discriminate against secondary materials as compared with virgin ones?

The question of whether existing railroad freight rates discriminate against secondary materials was examined using several models of transportation ratemaking. Such discrimination was found to be sizable for iron and steel, aluminum, paper, and glass under cost-based rates (both variable and fully allocated cost approaches) and for paper and glass under the chemical equivalency approach to value-of-service rates. Such discrimination was not found under the value-of-service approach to rates. This examination has shown that part of the long-standing controversy over discrimination against secondary materials arises from different assumptions about how rates ought to be set. (Chapter 3)

21 What effect would adjustment of freight rates have on shipments of secondary materials and on railroad revenues?

The amounts of secondary iron and steel, aluminum, and paper shipped by railroad are not very sensitive to freight rates, and large changes in rates would have little effect on shipments of these materials. Therefore, if freight rates for secondary iron and steel, aluminum, glass, and paper were to be adjusted downward (on the order of 30 to 50 percent) to eliminate the greatest degree of discrimination found using any of the ratemaking models examined, an economic model projects that increases in rail shipments for iron and steel, aluminum, and glass would be small—on the order of only a few percent. Glass shipments might increase by as much as 15 to 25 percent. Correspondingly, railroad revenues in each case would decline substantially since revenue losses from existing traffic would not be offset by revenues from traffic growth. (Chapter 3)

22 Should railroad freight rates for secondary materials be adjusted?

Regardless of the projected small increases in shipments and the large decreases in railroad revenues, however, secondary materials appear to be treated unfairly by existing freight rates in the case of iron and steel, aluminum, wastepaper, and glass. Both equity and economic efficiency argue for their adjustment. Railroad revenues, if inadequate, could be adjusted by general rate increases. (Chapter 3)

Issue Area III

Institutional Barriers to Resource Recovery and Recycling

Institutions are important in establishing or removing barriers to the emergence of centralized resource recovery, which is a new, uncertain and, therefore, risky technology for disposal of MSW. Many institutional barriers originate in the mixed system of Federal, State, and local governments. Therefore, policies must be designed to circumvent these barriers rather than to remove them. This study examined four classes of institutional problems: information problems, jurisdictional problems, implementation problems, and marketing problems. They are listed in table 2.

Table 2.—[illegible]

[illegible]
- [illegible] research and development.
- [illegible]

[illegible]
- Fragmented and overlapping State and local jurisdictions.
- [illegible]
- Mixture of private and public roles in managing MSW.
- Responsibility for and ownership of waste after discard ("flow control").
- [illegible] shipment or disposal.
- Overlapping Federal agency jurisdictions.

Implementation Problems
- Limited capability of local governments to issue bonds.
- Cooperation of local waste collectors and haulers.
- Creation of local monopolies.
- Insufficient definition of health, safety, and environmental standards for resource recovery plants.
- Siting of facilities.

Marketing Problems
- Inadequate or nonexisting standards of performance for recovered products.
- Limited authority of local governments to enter into long-term sales contracts
- Electric utility rate regulation that discourages use of new fuel sources
- High freight rates for shipping MSW and recovered materials.

SOURCE:Office of technology

Resource recovery poses economic risks to potential investors. These risks arise from uncertainties in technical performance, in product marketability, in waste composition, and in institutional forces. Each party to a resource recovery effort quite naturally tries to minimize the risks he faces, yet such risk avoidance has a price for all the parties involved. Finding ways to share the risks that derive from the technical and economic uncertainties of resource recovery is a major source of its institutional problems.

Three broad approaches are available to the Federal Government to address institutional problems: direct Federal action, Federal incentives to reduce risk and uncertainty, and Federal inducements to State and local governments. OTA has not attempted to rank the seriousness of these problems or to evaluate the effectiveness of various approaches to their solution. All of the problems are important. A mix of approaches is required to resolve them if resource recovery is to be widely adopted.

23 Can the Federal Government take direct action to overcome institutional barriers to resource recovery?

Since resource recovery is largely a function of local government, the power of the Federal Government to directly effect change is somewhat limited. For example, it can overcome problems caused by inadequate information by providing technical assistance to local governments, if such assistance is competent and unbiased. Congress could also consider legislation to ensure that resource recovery facilities are ruled eligible for pollution control revenue bond financing. Actions discussed in other issue areas would also be constructive, including promulgation of environmental and health standards for resource recovery (issue 8) and adjustment of railroad freight rates for secondary materials (issues 20 to 22). (Chapter 7)

24 Is there a role for the Federal Government in overcoming the risks of resource recovery?

Carefully designed Federal subsidy programs can help overcome the risk barrier faced by private entrepreneurs or public agencies when introducing new resource recovery technologies. Such a use of subsidies is conceptually different from their use to make projects appear economically feasible which otherwise would not be. The first use of subsidy for resource recovery is clearly justified, the second less so. (See also issue 26.) (Chapters 6, 7, and 8)

Federally funded research and development can also help overcome risks and solve the institutional problems that risk sharing creates. (See issues 4, 11, and 17.) (Chapters 3,4, and 5)

25 How important is Federal action to induce regional planning for resource recovery?

The Resource Conservation and Recovery Act of 1976 is strongly based on inducing States to institute regionalized planning for solid waste management. This approach makes sense if large-scale regionalized resource recovery offers sizable economic advantages through economies of scale both in processing wastes and in selling recovered energy. In view of recent trends toward small-scale resource recovery systems and in view of the difficulty of marketing large amounts of recovered energy, especially to electric utilities, the importance of regional planning for disposal of MSW has lessened. Federal efforts should allow for a great diversity of State and local approaches to the management of MSW. (Chapter 6)

Issue Area IV

Incentives for Resource Recovery and Recycling

The Federal Government could adopt any of a number of policies designed to improve the economics of resource recovery and recycling. These include policies designed to increase the supply of recovered materials, such as subsidies for building or operating resource recovery facilities, as well as policies designed to stimulate the demand for recovered resources by influencing the competition between virgin and secondary materials and energy.

Incentive policies are based on three general rationales. First, they can be designed to stimulate desired private resource recovery activity if such activity has been inadequate due to the fact that its net social benefits exceed its net private ones. Second, incentives can be designed to offset institutional barriers to resource recovery or to offset incentives already extended to competing virgin resources. Third, incentives can be designed to help overcome the risks that pioneering adopters face when trying a new, uncertain technology.

26 How necessary or desirable is Federal subsidy to increase the supply of recovered resources?

Subsidizing the capital or operating costs of centralized resource recovery nationwide cannot be justified on the basis of the economic value of the recovered energy or materials. For example, a subsidy of $8 per ton of MSW, which is designed to make an average $14 per ton resource recovery tipping fee competitive with an average $6 per ton landfill tipping 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 a 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 and 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; (z) 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 nonmonetary benefit of energy recovery such as reduced oil imports; or (3) if a subsidy for a small number of demonstration plants is used to compensate communities for bearing the risks associated with trying an uncertain new technology that might benefit 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. (Chapter 6)

27 What steps might the Federal Government take to affect the competition between virgin and secondary materials in order to stimulate demand for recycling?

This study has examined the potential effectiveness of five economic policies for stimulating recycling and reducing the rate of MSW disposal. They are:

The Product Charge—an excise tax levied on material goods proportional to their weight, volume, or other measure of disposal cost. The tax would be levied on material fabricators or related industries.

The Recycling Allowance—a direct grant or tax incentive to producers or users of recycled materials paid in proportion to some measure of the amount or value of recycled materials used.

The Severance Tax—a tax on virgin materials levied at the point of mining or harvest in proportion to some measure of the amount or value extracted.

The Percentage Depletion Allowance—existing law allows for deduction from income before taxes each year of a percentage of gross income from mining specified minerals. Repeal of this deduction was examined.

The Capital Gains Treatment of Income From Standing Timber—existing law allows for taxing income from the sale of standing timber at rates appropriate to long-term capital gains, which are lower than rates for ordinary income. Repeal of this tax preference was examined. (Chapter 8)

28 Which of the incentive programs for recycling might work best?

From equity, economic efficiency, and administrative perspectives, removing existing tax preferences for virgin materials is preferable to establishing new ones for recycled materials. From the perspectives of resource recovery, recycling, and reduced generation of waste, the key question, however, is the effectiveness of various proposals in stimulating recycling and decreasing the waste disposal burden,

Of the five policies considered, the product charge and the recycling allowance are projected to be the most effective for these purposes if they could be made to work. However, the effectiveness of the product charge would depend on the successful implementation of the exemption for recycled materials, but the administrative problems of the exemption may be so great as to render the charge concept unworkable. The recycling allowance faces similar administrative problems.

The analyses suggest that repeal of the percentage depletion allowance on hardrock minerals or repeal of the capital gains treatment of timber income would increase recycling by only a small amount. Furthermore, these actions are not expected to significantly reduce the generation of waste. (See also issue 29.) Nevertheless, these tax provisions do treat secondary materials unfairly in their competition with primary materials. (Chapter 8)

29 How much confidence is there in estimates of the effects of Federal incentives on recycling?

Only a small number of studies have been published on the response of recycling to economic policies, Further research and analysis are needed before there can be complete confidence in estimates of the effectiveness of Federal economic incentives in increasing either the demand for or the supply of recovered materials and energy. In particular, studies are needed concerning the influence of economic policy on plant investment decisions, including plant location, and on vertical integration in the materials industries to determine whether these effects serve to inhibit the use of recycled materials in the long run. Additional analyses are also needed to explore more fully the implications of these incentive policies for the nature of the competition between primary and secondary materials, and for the competition between domestic and foreign producers,

The incentive policies examined in this study may have side effects in such important areas as prices, profits, Government revenues, administrative costs, employment, foreign competition, and long-run materials and energy conservation. Further analysis indepth is needed to arrive at a thorough understanding of the outcomes of each of these policies. (Chapters 6 and 8)

Issue Area V

Beverage Container Deposit Legislation

During the last 30 years the beer and soft drink industries have undergone a major shift from the use of refillable glass bottles to the use of nonreturnable glass and plastic bottles and metal cans. During the same period the sales of both beverages in individual packages have grown dramatically. One result of these trends has been that discarded beverage containers have become significant components of both litter and MSW. Beverage delivery has become more energy- and materials-intensive while employing fewer people and requiring less capital per unit of beverage consumed. Economies of scale in brewing, bottling, and transportation, especially using lightweight nonreturnable containers, have favored a trend toward centralization of bottling and brewing, with fewer producers and fewer brands available. Packaging has become a significant part of beverage marketing strategy, with a wide variety of package sizes and types available. Federal legislation has been proposed that is intended to slow the declining market share of beverages in refillable bottles, by imposing a mandatory, uniform, refundable deposit on each container.

30 Would Beverage Container Deposit Legislation (BCDL) work?

A review of a number of studies of BCDL sponsored by proponents, opponents, and neutral parties finds agreement that it would accomplish all of its major goals to some degree. It would lead to a reduction in litter, in MSW, and in consumption of energy and raw materials. For its proponents, it would serve as a symbol of a commitment to resource conservation, even though it would not save as much energy as such measures as energy efficiency standards for buildings and automobiles.

However, considerable uncertainty exists regarding the ultimate effects of BCDL on container market shares and on return and recycle rates. No one has devised a method for predicting these outcomes, which depend on market decisions by consumers and on the exercise of at least limited market power by producers and distributors. Nevertheless, experiences in the several States that have implemented BCDL, as well as the judgment of many informed observers, indicate that BCDL would lead to an increased use of refillable bottles and that containers would be returned at a sufficiently high rate to ensure that its goals would be achieved. (Chapter 9)

31 How much energy would be saved by BCDL?

If BCDL were adopted it is estimated that it would save the energy equivalent of 20,000 to 60,000 barrels of oil per day. However, the energy saved would be in the forms of naural gas, coal, nuclear energy, hydropower, and wood waste. Some studies find a savings of oil as well. Other studies project an increase in the actual consumption of oil of as much as 5,000 barrels per day including additional gasoline and diesel fuel for transportation. (Chapter 9)

32 How would BCDL affect industry and labor?

BCDL would have a number of significant side effects that are not intended by its proponents. It would increase the capital needs of beverage brewers, bottlers, wholesalers, and retailers. At the same time, it would severely disrupt the metal can and glass bottle industries with losses of output and jobs. Net employment and total compensation to workers would increase for the industries involved in manufacturing materials and containers, and in producing, delivering, and selling beverages. However, existing skilled jobs would be lost in materials and container production, while relatively unskilled jobs would be gained in wholesaling, transportation, and retailing of beverages.

The costs of BCDL would be concentrated in a small number of communities in which materials and container plants are located, while the benefits would be distributed throughout the country. Thus, Federal relocation, retraining, and other assistance should be considered for both workers and firms that might be harmed by BCDL. (Chapter 9)

33 How would BCDL affect consumers?

Unlike a ban on nonreturnable containers, BCDL would preserve the right of producers and consumers to choose among several package types, although the total number of available package types would decline. However, BCDL would ensure that users of nonreturnables pay the full cost of their disposal. It would also provide an incentive for recycling and against littering.

Under BCDL, the costs of containers per fill would decline due to the greater use of multitrip refillables, while other costs of delivery would increase. Available data do not permit a consensus judgment of the net effect of BCDL on total costs, or on the shelf prices of beer and soft drinks. Some authors project a decrease in costs and prices, others an increase. Data on current prices show that soft drinks are cheaper in refillables than in nonreturnable bottles and cans. There is some reason to believe that this might not be the case under BCDL if producers have to invest heavily in new equipment to meet an augmented demand for beverages in refillables.

The availability of beverages in refillable containers is expected to improve under BCDL, whereas the number of types of containers might decline. Depending on how consumers value the convenience of nonreturnables and refillables as well as on the uncertain price changes, beverage consumption might decline, but by a few percent at most. (Chapter 9)

34 What would be the impact of BCDL on health and the environment?

Refillable containers generally produce less air and water pollution and less industrial solid wastes than other container types on a per-fill basis. Litter-related injury from improperly discarded glass bottles would probably decline under BCDL. It is not possible to say with available data whether worker and consumer injury would increase or decrease. No evidence was found that refillable glass bottles pose additional health or sanitation hazards. (Chapter 9)

35 How might BCDL affect, or be affected by, new technology?

If BCDL were passed, new technology might emerge for managing refillable containers and for recycling nonreturnables. Government assistance might be needed to spur development of new, more efficient, standard refillable containers for use industrywide.

The growing popularity of the plastic soft drink bottle could drastically alter the soft drink package mix, whether or not BCDL is adopted. If made available in smaller sizes (10 to 16 ounces), plastic containers would markedly alter the projections of the effectiveness and the impacts of BCDL that are discussed in this report. (Chapter 9)

36 How would BCDL affect economic concentration in the soft drink and beer industries?

Since BCDL would decrease the economic advantages of centralized brewing, bottling, and wholesaling, the current trend toward a small number of large firms in beer and soft drink production might be slowed.

If upheld by the courts and not modified by Congress, the recent decision by the Federal Trade Commission outlawing territorial franchise restrictions for trademarked soft drinks in nonreturnable containers could lead to rapid concentration of that industry. The results would be an industry with only a few firms having a few large plants, as well as the rapid disappearance of the refillable bottle for soft drinks. By making the refillable bottle more attractive economically, BCDL could help preserve smaller, local bottlers. Legislation now under consideration to preserve the territorial franchise system could help maintain the refillable bottle's current market share.

The beer and soft drink industries are both complex. They are characterized by a mix of small and large firms, by regional and national markets, and by an extensive use of packaging alternatives as marketing and competitive devices. None of the major analyses of the effects of BCDL examined for this study has taken these structural complexities into account. In part, this reflects the limits of the art of policy analysis. It also contributes to the inherent uncertainty regarding the ultimate outcomes either of BCDL or of antitrust action taken against the industries. (Chapter 9)

37 How would BCDL affect government?

BCDL would cause some shift in tax revenues at and among the local, State, and Federal levels. This would happen due to changes in the mix of capital and labor used in the beverage-related industries and to changes in profits and wages. While BCDL uses the market approach to regulation and is nearly self-administering, some additional governmental resources would be needed to administer and police the deposit system. (Chapter 9)

38 Would BCDL harm centralized resource recovery or source separation programs?

Successful BCDL would reduce the amount of aluminum, steel, and glass in the solid waste stream. Thus, it might reduce the revenue of an existing centralized resource recovery plant by as much as 5 percent. There would be no revenue reduction at all if the recovery of aluminum and glass do not become technically and economically feasible. Systems such as waterwall incineration, which do not recover materials, would not experience a loss in revenues. (Chapters 5, 6, and 9)

Source separation programs are more dependent on revenues from materials recovery than is centralized resource recovery. Thus, BCDL might reduce the potential revenues of a residential source separation program for newspaper, glass, and cans by as much as 25 percent, or of a comprehensive program including all forms of paper and yard wastes by as much as 13 percent. (Chapters 4 and 9)

A Perspective on Further Federal Action

The disposal of MSW in an environmentally and economically acceptable manner is a chronic problem of our modern consumer society. Recovery, recycling, and reuse of the materials and energy in MSW can help solve the disposal problem and provide opportunities to conserve resources and protect the environment.

Like all of man's activities, resource recovery, recycling, and reuse have costs as well as benefits. This study of proposed Federal policies for waste management has not adopted the overly restrictive formalism of the cost/benefit approach. Nevertheless, it is reasonable to regard resource recovery, recycling, and reuse from an economic perspective and to urge that such programs make economic as well as political sense.

In the context of current costs, prices, and markets for materials, labor, and equipment, resource recovery is economically sound in some regions and not in others. In those regions where the cost of environmentally sound landfill or the price of energy is high, or the markets for recovered materials are strong, resource recovery and recycling make good economic sense. In other regions, landfill is still the economically and environmentally preferred alternative. Federal policy should be sufficiently flexible to accommodate different local conditions, and should encourage State and local governments to adopt the most economic and environmentally sound approach to waste disposal. The focus of Federal policy needs to remain on those areas in which the private market and State and local governments require the most assistance: protecting public health, preserving the natural environment, and supporting research and development on new technology.

This study has identified and examined a number of Federal policy options, each of which alone would make only a small difference to the economics of resource recovery and recycling. Taken all together, however, they could lead to a large increase in these activities. Ultimately, the widespread adoption of resource recovery and recycling may depend not so much on the objective analysis of small actions taken either together or separately, but on Federal action to create a climate in which the recovery, recycling, and reuse of discarded wastes becomes a valued way of life for all Americans.

Chapter

Introduction and Framework for Analysis

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Introduction and Framework for Analysis

Objectives and Scope

Society's primary interest in resource recovery, * recycling, and reuse arises from the need to dispose of municipal solid waste (MSW) from residences, institutions, commercial establishments, and light industry. Resource recovery, recycling, and reuse can be constructive supplements to less desirable traditional disposal methods such as open dumping, landfill, uncontrolled incineration, and ocean burial. In addition, it can contribute to the wise and efficient use of materials, to conservation of energy, to preservation of the environment, and to improvement in the balance of trade through reduction of the Nation's dependence on imported natural resources. By using materials more than once, virgin resources can be conserved for ourselves and for future generations.

The objectives of this study are:

1. To identify the technological, economic, and institutional factors that influence the generation, recovery, recycling, and reuse of MSW.
2. To identify Federal policy options that could be adopted to reduce the rate of generation of MSW or to stimulate the recovery, recycling, and reuse of the resources it contains.
3, To analyze the effectiveness of the policy options, and to assess their impacts and the issues that accompany each of them.

The scope of this study is limited to the generation and disposal of ordinary MSW in the United States. Specifically excluded from consideration are the management of hazardous wastes, sewage sludges, or other special wastes; the remanufacture, reworking, or refurbishing of products for reuse; the recycling of industrial scrap; and the recovery of materials or energy from agricultural, forestry, mining, or industrial residues.

The following specific issue areas are addressed:

1. Potential markets for recovered materials and energy, including the effects of railroad freight rates and product quality specifications. (Chapter 3)
2 The status of technologies and approaches for resource recovery and recycling, including small- and large-scale centralized processing and separate collection. (Chapters 4 and 5)
3. Economics of the construction and operation of large-scale centralized resource recovery facilities. (Chapter 6)
4. Institutional considerations in implementing resource recovery and waste reduction programs. (Chapter 7)
5. Education, training, technical assistance, and research and development for resource recovery, recycling, and reuse. (Chapters 4,5, and 7)
6. Financial options and incentives for influencing the relative costs of virgin and secondary materials. [Chapter 8)
7. The effectiveness and impacts of beverage container deposit legislation. (Chapter 9)
8. The nature of the interactions between programs for centralized resource recovery, source separation, and beverage container deposit legislation. (Chapters 4,6, and 9)

*See the Glossary at the end of this report for definitions of the terms used.

Approach

The study was carried out during the period from January 1976 to June 1978 by OTA staff, contractors, and consultants. Contractors and consultants collected and analyzed data, prepared models, and wrote papers, which have been published in the Working Papers volume. Several workshops were held to get the views of interested parties. OTA staff made a number of site visits to existing facilities and programs, participated in congressional hearings and briefings, and benefited greatly from individual contacts with persons in the field.

The overall framework for the analysis, discussed further below, consisted of an examination of the technological, economic, and institutional factors that influence resource recovery, recycling, and reuse. An attempt was made to analyze or assess all these factors and all the relevant policy options for addressing them. The emphasis was on the effectiveness of each option or strategy in accomplishing the goals of' product reuse, reducing waste generation, and recovering and recycling materials and energy from MSW.

The Municipal Solid Waste Problem

Background

Solid waste disposal is a growing problem in many parts of the country for three reasons: (i) unsanitary disposal in open dumps or uncontrolled landfills poses health and safety hazards and esthetic problems that are no longer deemed acceptable; (ii) landfill sites are becoming increasingly difficult to obtain as citizens resist their development, as land values increase, and as higher water quality standards render many areas geologically unsuitable or too expensive for controlled landfill; and (iii) stricter air and water pollution standards make uncontrolled incineration, open burning, and ocean dumping unacceptable disposal alternatives.

In 1976, the national average cost to collect and dispose of 1 ton of MSW was reported to be $30.(1) It was as high as $50 per ton in some areas. In recent years, modern management methods and new technology have helped to control the cost of collection, which has typically been 70 to 80 percent of the total. Disposal costs, however, have increased rapidly as the problems mentioned above have emerged. The. Nation, concerned about the growing disposal burden and motivated by the prospect of materials and energy conservation, has begun to look toward resource recovery, recycling, and reuse as alternatives to disposal of a significant portion of MSW.

In 1975, an estimated 136 million tons of MSW was generated nationwide, an average of nearly 3.5 pounds per capita per day.(2) At $30 per ton, the cost to manage these wastes totaled over $4 billion in 197'5. The Environmental Protection Agency (EPA) has projected that waste generation rates will continue to grow, based on current trends and policies.(3)

One way to consider the potential for resource recovery, recycling, and reuse is to examine the composition of MSW on a nationwide, annual average basis, as shown in table 3.* The content, on a weight basis, of metals and "garbage" (food wastes) is relatively small. The content of combustible materials that can be burned to provide energy is nearly 80 percent of the total wet weight of MSW.

Another way to consider the composition of MSW is in terms of the product origins of the materials it contains as shown in table 4. Over 50 percent of the weight of MSW consists of paper and packaging, which are largely transitory goods. Over 51 percent of the aluminum, 46 percent of the glass, and 12 percent of the iron and steel come from beverage containers (beer and soft drinks).

*Accurate data on the amount and composition of MSW are not available. EPA's estimates are based on a materials flow approach that considers production rates and lifetimes for each product, rather than on actual measurement of wastes.(3)

Table 3.— Material Composition* of MSW in 1975

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

* The compositton reflects considerable geographic and seasonal variation, especially for the content of metals and yard wastes Furthermore, accurate composition data are difficult to obtain due to problems in obtaining representative samples of waste streams 1975 is the most recent year for which detailed composition estimates have been published by EPA

SOURCE U S Environmental Protect (on Agency Off Ice of Solid Waste Management Programs, *Resource Recovery* and Waste Reduction, Fourth Report to Congress, EPA Publicaton SW-600, Washington, D C U S GPO 1977, p 18

Another perspective on the potential of resource recovery from MSW can be gained by its contents as generated to total domestic consumption of its various components as shown in table 5. These data show that resources recovered from MSW could provide a substantial source of supply for some materials and could contribute to the Nation's supply of energy.

Federal Involvement in Solid Waste Problems

Rationale

Municipal solid waste collection and disposal have traditionally been the responsibility of State and local governments, with the latter bearing the primary burden. In the last two decades, however, the Federal role has expanded considerably, for several reasons.

First, the Federal Government has helped to create some of the problems faced by localities. For example, certain tax policies have encouraged the development and use of virgin materials. At the same time, increasingly stringent Federal environmental legislation has outlawed some disposal options and made others more expensive.

Second, the environmental problems created by improper disposal of wastes do not respect State boundaries. Water pollution from landfills and dumps, and air pollution from incineration and open burning often cross State lines, indicating a clear need for Federal coordination or action.

Third, the Federal Government has available a wider variety of policy tools for avoiding or managing waste disposal than do State and local governments. For example, most scrap materials are traded in volatile national markets over which State and local governments can exert little influence, whereas the Federal Government might undertake stockpile or subsidy programs to stabilize or strengthen markets. Only the Federal Government oversees railroad freight rates for materials. While State or local governments may have the power to levy product disposal charges, most are unlikely to do so because of the competitive disadvantage created by such unilateral local actions.

Fourth, the Federal Government can assume responsibility for funding research, development, and demonstration programs for which the expense or risk would be unreasonably high for a local government or an individual firm, but well worth it for the Nation as a whole. Likewise, Federal resources can be efficiently brought to bear on education, training, and information dissemination.

Fifth, the Federal Government can best represent the long-term national interest in recovering, reusing, and recycling materials for improving our balance of trade with other nations and for conserving materials for use by future generations.

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Table 4.—Product Composition of MSW in 1975
(1,000 tons)

Product category	As discarded	Net waste disposed of after recycling: Quantity	Net waste disposed of after recycling: % of total waste	Net waste disposed of after recycling: % of nonfood product waste
Durable goods:	14,740	14,350	11	19
Major appliances	2,430	2,280	2	3
Furniture, furnishings	3,370	3,370	3	4
Rubber tires	1,790	1,600	1	2
Miscellaneous durables	7,150	7,100	5	9
Nondurable goods, exe. food:	24,140	21,365	17	27
Newspapers	8,850	7,020	5	9
Books, magazines	3,075	2,820	2	3
Office paper	5,210	4,510	4	6
Tissue paper, inc. towels	2,235	2,235	2	3
Paper plates, cups	485	485	—	—
Other non packaging paper	1,045	1,045	1	1
Clothing, footwear	1,250	1,250	1	2
Other miscellaneous durables	1,990	1,990	2	3
Containers and packaging:	46,550	41,740	33	54
Glass containers	12,520	12,150	10	16
Beer, soft drink	6,345	6,095	5	8
Wine, liquor	1,790	1,760	1	2
Food and other	4,385	4,295	3	6
Steel cans:	5,525	5,225	4	7
Beer, soft drink	1,340	1,275	1	2
Food	3,195	3,035	2	4
Other nonfood cans	760	720	1	1
Barrels,drums, pails, misc.	230	220	—	—
Aluminum:	770	685	1	1
Beer soft drink*	510	430	—	1
Other cans	25	25	—	—
Aluminum foil	235	230	—	—
Paper, paperboard:	23,135	19,080	15	25
Corrugated	12,520	9,745	7	13
Other paperboard	5,470	4,750	4	6
Paper packaging	5,145	4,585	4	6
Plastics:	2,635	2,635	2	3
Plastic containers	420	420	—	—
Other packaging	2,215	2,215	2	3
Wood packaging:	1,800	1,800	1	2
Other miscellaneous packaging	165	165	—	—
Total nonfood product waste	85,430	77,455	61	100
Food waste	22,785	22,785	18	29
Yard waste	26,010	26,010	20	33
Miscellaneous inorganic wastes	1,900	1,900	1	2
GRAND TOTAL	136,125	128,150	100	164

*Includes all-aluminum and aluminum ends from bimetallic cans

SOURCE US Environmental Protection Agency, Office of Solid Waste Management Programs, *Resource Recovery and Waste Reduction,* Fourth Report to Congress, EPA Publication SW-600, Washington, DC, U.S GPO,1977, p 17

Table 5.—Comparison of Materials and Energy Content of MSW to Total U.S. Consumption in 1975

MSW component	MSW content[a] as a percentage of consumption
Ferrous metal	12
Aluminum	22
Other nonferrous metal	5
Glass	69
Paper	67
Energy[b]	1.9

[a]MSW as discarded Some portions of each material are recovered for recycling before disposal See table 3
[b]Includes fuel value of paper
SOURCE Off Ice of Technology Assessment

Finally, local solid waste management problems are highly visible and, unlike many other local problems, may be resolvable by the application of sufficient money and technical know-how.

History

Three major laws have prescribed the Federal role in solid waste management: the Solid Waste Disposal Act of 1965, the Resource Recovery Act of 1970, and the Resource Conservation and Recovery Act of 1976. Several other acts have had a lesser influence. *

Federal involvement in the problems of MSW management was first established under the Solid Waste Disposal Act of 1965, which is part of the Clean Air Act Amendments (Public Law 89-272, 79 Stat. 992 (1965)). The Act recognized the association of solid waste disposal, air pollution, and waste generation rates, and provided for designing and testing new methods for solid waste disposal and resource recovery. It also provided technical and financial assistance to States and to interstate agencies for planning resource recovery and solid waste disposal programs. It was originally administered by the Department of Health, Education, and Welfare, but in 1970 the responsibility was transferred to the newly formed EPA.

*See appendix A for a more detailed discussion of existing laws on solid waste management.

The 1965 Act was amended by the Resource Recovery Act of 1970 (Public Law 91-512, 84 Stat. 1227 (1970)). The amendment recognized the special disposal problems of hazardous wastes. It established the need to examine a national materials policy to conserve resources and protect the environment through Title II, the Materials Policy Act of 1970, which established the National Commission on Materials Policy.(6) The Act, as amended, required annual reports to the Congress on studies of various waste-generation, materials recovery, and waste disposal options, practices, and policies. Under the Act, the EPA Administrator could fund resource recovery demonstration projects; award grants for State, interstate, and local planning; and recommend guidelines for solid waste recovery, collection, separation, and disposal systems.

The Resource Conservation and Recovery Act of 1976 (Public Law 94-580, 90 Stat. 2795) was enacted and signed during the last days of the 94th Congress. This Act is designed to establish broad new programs, including comprehensive regulations for the management of hazardous wastes; to provide incentives for regionalized solid waste planning; and to accelerate research, development, and demonstration. The Act provides that, in order to receive Federal planning funds, State plans must ban open dumps and require all sanitary landfills to meet environmental criteria to be set by EPA. Section 8002(j) of the Act established the interagency, Cabinet-level Resource Conservation Committee charged with investigating a variety of resource conservation measures for possible future actions.

A number of other recent laws have had important implications for solid waste management and resource recovery. The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500, 86 Stat. 816), as amended by the Clean Water Act of 1977 (Public Law 95-217, 91 Stat. 1566) treat solid waste disposal sites as nonpoint sources of water pollution. The Federal Ocean Dumping Act of 1972 (Public Law 92-532, 86 Stat.

1051) as amended in 1974 (Public Law 93-254, 88 Stat. 50) prohibits ocean dumping of hazardous wastes, and requires a carefully defined permit for ocean disposal of MSW. This law has nearly eliminated such ocean disposal.

The Secretary of the Treasury, with the cooperation of EPA, is required by Public Law 94-568 (90 Stat. 2697), which amends the Internal Revenue Code of 1954, to investigate all provisions of the Internal Revenue Code that impede or discourage recycling of solid wastes, and was to report his findings by April 20, 1977, to the President and Congress with specific legislative proposals and detailed estimates of their costs. Activities under this Act, however, have been subsumed under the ongoing interagency Nonfuel Minerals Policy Study* ordered by the President on December 12, 1977.(7)

The Railroad Revitalization and Regulatory Reform Act of 1976 (Public Law 94-210, 90 Stat. 30) required the Interstate Commerce Commission to investigate the structure of freight rates for recyclable materials. The Commission's actions, and subsequent court actions, are discussed in chapter 3 of this report.

The Emergency Interim Consumer Product Safety Standard Act of 1978 (Public Law 95-319, 92 Stat. 386) established an interim consumer product safety rule relating to the standards for flame resistance and corrosiveness of cellulose for home insulation. Cellulose insulation is made from recycled newspaper treated with fire retardant. The intent of the Act was to guard against fire hazards from insulation treated with inadequate amounts of fire retardant.

The Energy Tax Act (Public Law 95-618, 92 Stat. 3174) contains two provisions that should influence recycling. One provides an additional lo-percent investment tax credit (for a total of 20 percent) for the purchase of equipment used to recycle ferrous (with certain exceptions) and nonferrous metals, textiles, paper, rubber, and other materials for energy conservation. The additional credit is available for a wide range of equipment placed in service after October 1, 1978. The other provides for setting recycling targets for major energy-consuming industries. These include the metals, paper, textile, and rubber industries. Specific targets will be set for the increased use of recycled commodities over the next 10 years.

For legislation affecting solid waste management, resource recovery, recycling, and reuse considered by the 95th Congress, see appendix B.

*On Feb. 1, 1979, the Department of the Treasury published the report, Federal Tax Policies: Recycling of Solid Waste Materials, in response to Public Law 94-568 and the ongoing interagency Nonfuel Minerals Policy study. The report was also given to the Resource Conservation Committee which was established under the Resource Conservation and Recovery Act of 1976.

Framework for the Analysis of Resource Recovery, Recycling, and Reuse

This section sets forth a general framework for the analysis of issues and options. The materials system concept is used to illustrate the various ways in which recovered materials can reenter the materials cycle. The roles of technology, economics, and institutions are explored for the insights they provide. Finally, guidelines for the analysis of the available options are discussed.

The Materials System and Policy Options

The traditional view of the materials system as seen by local MSW managers is modeled in figure 1. Those responsible for the management of MSW have exercised little or no control over the other parts of the materials system. They have only been involved with the last two steps, collection and disposal.

The comprehensive materials system model shown in figure 2 displays a wide variety of opportunities for Government and for the private sector to affect the flow of materials toward ultimate disposal through reuse and recycling. Some of the major public policy op-

Figure 1 .—A Simple Model of the Materials System With No Reuse or Recycling

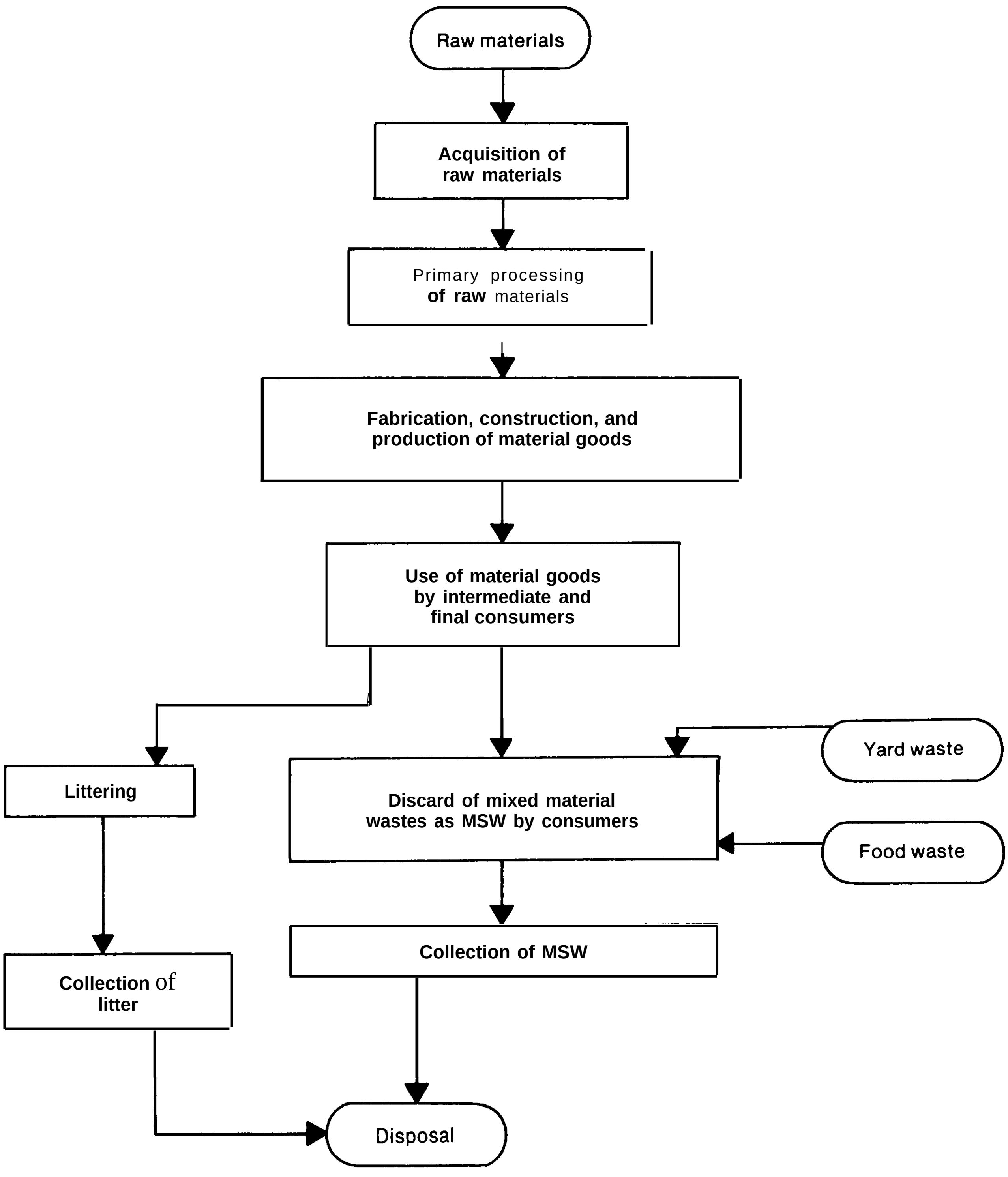
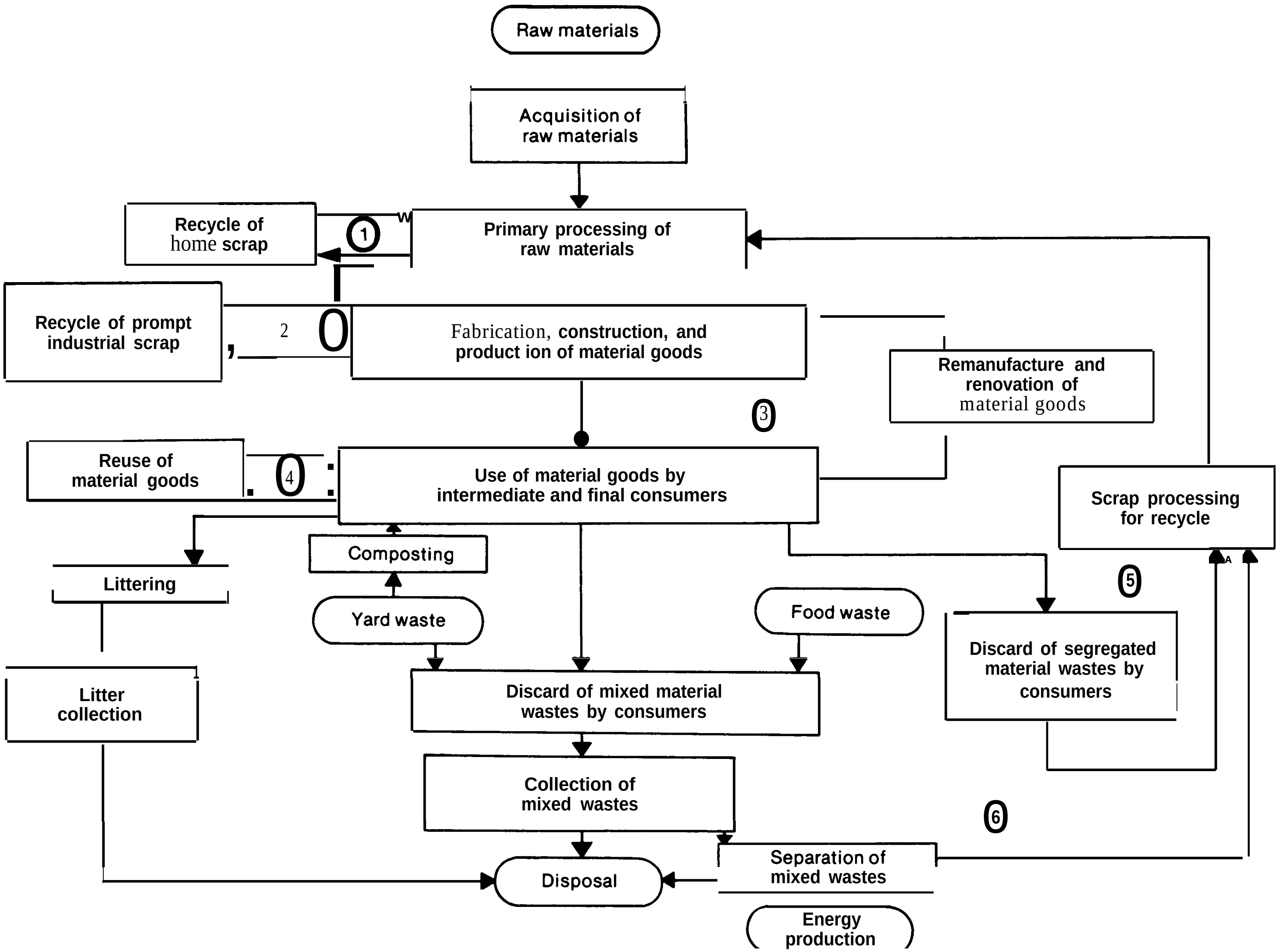


Figure 2.—A Complex Model of the Materials System Showing a Variety of Recycle Loops and Disposal Options



ions available for modifying the structure and functioning of the materials system are the subject of this report. The nature of many of these options is revealed by examination of the technical, economic, and institutional influences on the materials system.

The materials system model in figure 2 contains six pathways or loops by which materials are recycled or reused prior to ultimate disposal. Loops 4, 5, and 6 are within the scope of this study; loops 1, 2, and 3 are not. The six loops are:

1. Home scrap recycle.
2. Prompt industrial scrap recycle.
3. Product remanufacture or renovation.
4. Reuse of material goods.
5. Recycle of segregated wastes.
6. Recovery of energy and materials from mixed wastes.

Loops and 2 represent the long-established industrial practices of immediately recycling either home scrap within the primary materials processing facility or rompt nciustrial scrap from fabricators directly back to such processors. Loop 3 represents a variety of rework practices. These include the remanufacture of auto parts, the refurbishing of telephones, the renovation of standing buildings, and the repair and sale of used clothing and appliances by handicapped workers. The characteristics of materials flows in home and prompt scrap and in product rework are currently under study in another TA project.(8)

Loop number 4 represents direct reuse of material goods with little or no change in form. Typical examples of reuse include return of beverage containers for refilling, reuse of "used cars" by second or third owners, and reuse of shipping pallets.

Loop number 5 represents recycling discarded material wastes, which are segregated by material type at each stage in the loop. One example of this approach is separate collection of one or more components of municipal waste. This is practiced in a number of areas, often by curbside collection of newspapers, glass, and cans; by collection of corrugated cardboard at commercial establishments; or by "paper drives" sponsored by nonprofit organizations. A second example is "community recycling" in which nonprofit organizations or local governments provide facilities at which citizens can drop off onmixed wastes such as paper, cans, bottles, and waste oil. A third example is aluminum can recycling centers operated by aluminum manufacturers or beverage companies. In each of these examples the segregated wastes can be easily processed because they are kept relatively free of contamination.

Loop number 6 represents recycling mixed wastes, which are separated to recover materials and fuel or burned in mixed form to produce energy. In either case a residue remains for ultimate disposal. One example of this kind of recycling is the shredding of automobile hulks to remove nonmetals and to produce one or more recyclable metallic components. Another example, which is of primary interest in this study, is the separation and/or combustion of mixed SW in centralized resource recovery plants. This method may be able to produce various recyclable materials such as ferrous metals, aluminum, glass, and mixed nonferrous metals; as well as such energy products as refuse-derived fuel, steam, electricity, pyrolytic gas or oil, or biologically produced methane gas.

Finally, figure 2 shows yard waste being returned to users as compost or mulch. This can be done by individuals at home, or by collection, comporting, and redistribution of such waste as compost and mulch, as is practiced in some communities.

Technical Characteristics of the Materials System

The flow of materials through the materials system obeys certain physical laws. Matter is neither created nor destroyed. Its physical and chemical form, however, can undergo change, and some matter is lost to the environment as it moves through the system. In addition, energy is needed to drive the flow of materials through the system.

These physical laws imply that (i) some new materials must be acquired to make up for any losses; (ii) there will always be some residuals left as a result of the materials flow; and (iii) in principle, all materials can be accounted for as they flow through the system. This means that in either a static or a growing economy in which there is no technological change, recycled materials can satisfy only part of the need for materials. Furthermore, regardless of the effectiveness of the materials and energy recovery system used, some residual SW will always require disposal.

As materials move through the system from acquisition to disposal, it becomes increasingly difficult to recover, recycle, or reuse them. They may become part of manufactured goods in which they are firmly combined with other materials and thus not recoverable unless products are designed to facilitate reuse and recycling. Materials may also become so widely dispersed that they are essentially irretrievable. Paint pigments, chrome plating, and copper wire in automobiles, for example, cannot be recovered economically, if at all.

The technologies needed to move materials along each of the six recycle pathways shown in figure 2 are currently at different stages of development. This reflects the level of historic interest in each recycling method, the different states of the scientific knowledge base necessary to develop such technology, and the differing levels of technical difficulty presented by each recycling approach. For example, the technologies needed to reuse beverage bottles reached their current stage of development years ago. Modern engineering and management methods could probably improve them significantly. Yet economic interest in improving such systems over the last 20 years has not been sufficient to stimulate the necessary applied research. As another example, currently large sums of money and considerable technical talent are being devoted to developing, demonstrating, and improving methods for the challenging task of separating SW into useful components.

The connections between materials flows and energy consumption are neither simple nor obvious. On the one hand, combustion of SW is often cited as a potential energy source. On the other hand, recycling or reuse of some of the combustible components of SW such as paper or plastic may conserve more energy than would have been produced by burning them. Also, while the production of materials consumes energy, carefully designed energy-conserving structures or machines may use more materials than would be used in alternative designs that consume more energy. In these as well as in other cases, the relationship between materials and energy must be carefully examined—no general principle of co-conservation exists.

Some resource recovery, recycling, and reuse options may employ technologies that are more sophisticated than others. This is an insufficient reason to justify orientation of public policy toward the adoption of either "high" or "low" technology approaches. The various technical approaches to resource recovery, recycling, and reuse may be mutually supportive and compatible. Thus, the wisest policy may be to allow for the choice of a mix of approaches based on technical capabilities, economic costs, and political realities.

Economic Characteristics of the Materials System

The flow of materials in the materials system is influenced by economic forces, as well as by other factors such as technological possibilities. An overview of the economic nature of the materials system, including forces created by existing Government policies, can highlight opportunities for public policy initiatives in the resource recovery, recycling, and reuse area. An understanding of the economics of the materials system is also useful in identifying and analyzing the implications for the various parts of the system of changes in one or another of its parts.

A fundamental principle of market economics applicable to the materials system is that there is a tendency in the short run and a much stronger tendency in the long run for the buyers and sellers of materials to respond to prices, costs, and profitability considerations. For example, all other things being equal, consumers will purchase the cheapest of two or more products, and producers will incorporate the lowest priced materials in their products. The significance of this economic principle is that economic incentives such as taxes, charges, deposits, subsidies, depletion allowances, and the like can influence the flow of materials through the system.

A number of specific observations about the behavior of the materials system follow from economic principles:

1. The rates of flow of each material between various stages in the materials system depend on the material's price; the prices of all other materials, goods, and services in the economy; the level of technical knowledge; prior capital investments; and consumer demands.

2. Consumer demands for materials ultimately depend on consumer tastes. These can change to reflect changing economic, political, moral, and spiritual values.

3. The demand for materials is largely derived from the demand for the goods that are made from them. Since material costs are usually a small fraction of the costs of final goods, the demand for a material is often relatively insensitive to a change in its price in the short run. Over longer periods of time, material demand will change as producers adjust to changing prices by investing in new capital equipment designed to use less expensive or more available material inputs.

4. A host of existing Government programs affect the costs and relative prices of materials and thus influence their rates of flow in the materials system. Such programs as income and property taxes, environmental regulations, and various subsidies may be intended to accomplish other social goals and may shift the patterns of materials flow only as side effects.

5, A variety of direct and indirect subsidies that tend to reduce material costs are listed in table 6. Such subsidies, whose benefits accrue both to the materials industries and to users of materials, are designed to accomplish various public purposes. Their consequence, however, is that not all the costs of the production and use of materials are reflected in their market prices.

64 The primary materials acquisition and processing industries are capital-intensive with large fixed costs of operation. At the same time, the demand for basic materials varies strongly with the general state of the economy. To avoid the burden of paying high fixed costs in periods of low demand, the basic materials industries try to meet peak demands by using more scrap raw materials. As a result, the demand for secondary materials fluctuates and is highest when overall materials demand is high. Fur-

Table 6.—Selected Subsidies in the Materials System

Direct subsidies
- —percentage depletion allowance for virgin minerals
- —capital gains treatment of timber income
- — accelerated depreciation for capital investments
- —tax credits for investment in new capital equipment
- —tax deductions for interest payments

Indirect subsidies
- — royalty-free access to virgin materials on public lands
- —Government funding for highway construction and support for railroad operations
- —differential freight rates for various materials
- —free use of domestic waterways
- —educational benefits for training of professional and skilled labor
- —Government R&D on materials production and use
- — forest product R&D and technical assistance
- — low-cost use of clean air and water
- —low-cost use of worker health and safety
- –Government production of geological and mapping data

SOURCE Office of Technology Assessment

thermore, in periods of high economic activity and consequent high secondary materials demand, prices for secondary materials rise. Thus, scrap demand appears to increase with its price, when, in fact, its price increases with demand. One implication of these observations is that policies designed to stimulate the demand for scrap are likely to be more effective in assisting resource recovery, recycling, and reuse than are policies designed to increase the supply of scrap.

7. In most communities, consumers pay uniform charges for solid waste collection and disposal, or such costs are met by local property taxes. In either case, there is less incentive to avoid waste disposal or to seek recycling or reuse alternatives than there would be if full collection and disposal costs were paid for each discarded item.
8. The social costs of litter (collection, esthetic loss, personal and wildlife injury, machine damage, law enforcement) are higher than the cost to the litterer of proper disposal. Therefore, policies that provide incentives to avoid littering are likely to be more cost effective than those that provide for increased collection activity.
9. The economic system, which discounts the future costs and benefits of current actions, does not take into consideration the long-run exhaustion of high-grade natural resources as it would if the interests of future generations were taken into account.

Institutional Characteristics of the Materials System

In our society, the forces of economics and the capabilities of technology are often constrained or enhanced by institutional influences arising from geography, historical development, tradition, political action, or other exercise of power.

Some institutional factors are specific to the materials system and may be readily susceptible to alteration in pursuit of the goals of resource recovery, recycling, and reuse. An example of this kind of institution is a design specification that requires the use of virgin materials when recycled materials might perform equally well.

Other institutional factors are parts of the total cultural framework and are much less susceptible to manipulation in the interest of resource recovery, recycling, and reuse. An example is the fragmented, overlapping system of local, regional, State, and Federal responsibilities for government. This system tends to inhibit the adoption of efficient methods for control of waste generation and for management of wastes. It cannot, however, be significantly altered solely to accomplish these particular social purposes.

Table 7 lists selected institutional characteristics of the materials system. These have been chosen to illustrate institutional barriers to resource recovery. Some serve important social purposes and should not be changed to accommodate recycling. In such cases, it may be better to add new institutions or to adopt compensatory economic incentives. In other cases, institutional barriers can be overcome by new legislation or regulation.

Some institutional characteristics of the materials system could be equally classified as economic. For example, historic investments in primary processing facilities designed to use virgin ore contribute to the large size and vertical integration of virgin materials producers. This economic activity has created an institutional barrier to recycling postconsumer scrap. Some analysts have argued that many institutional forms, including Government policies, have economic roots. While the distinction may be somewhat arbitrary, it provides a useful part of the analytic framework in later chapters.

Guidelines for the Analysis of Policy Options

Several guidelines have been used to focus the analysis of policy options. These guidelines, which reflect the diverse goals of our

Table 7.— Selected Institutional Characteristics of the Materials System That Are Barriers to Resource Recovery

Industry structure and practice
- —entrenched local interests in collection and outmoded disposal methods for MSW
- —local or national economic concentration in the materials industries
- —vertical integration in the virgin materials industries
- — small size of secondary materials firms
- —joint ownership of transportation and virgin materials firms
- —declining quality of some rail freight service
- —fluctuations in secondary material demand and prices
- —use of advertising and packaging as a means of product differential ion

Regulatory practices
- — regulation of freight rates
- — material design or purchase specifications that require use of virgin materials
- —electric utility rate regulation that discourages risk-taking with nontraditional fuels
- —limitations on interjurisdictional transfer and disposal of wastes
- —delay in promulgating environmental and occupational standards for new resource recovery technologies

Government limitations
- —limited enforceability of anti litter laws
- —limited ability of the political process to respond to tradeoffs between the loss of existing jobs and the creation of new ones
- —fragmented and overlapping nature of Government responsibility for waste problems
- —difficulty of local government cooperation
- —absence of technical and marketing skills in local governments
- —limitations on local government participation in long-term contracts

SOURCE Office of Technology Assessment

society, provide a basis for illuminating the tradeoffs among society's goals that are required when a policy for resource recovery, recycling, and reuse is adopted. The guidelines are:

1. Technical, administrative, and political feasibility;
2. Economic efficiency;
3. Equity and participation;
4. Ecological, national, and personal security; and
5. Diversity and complementarily.

In certain parts of this study these guidelines are used explicitly as criteria for the assessment of options. In other parts, they are implicit in the discussion. In the following paragraphs, the application of these guidelines to materials policy is outlined.

The technical, administrative, and political feasibility guideline concerns the implementation and workability of a proposed policy. Is the necessary technology available, or can it be developed within a meaningful time frame? Are the political interests alined in such a way as to allow a reasonable chance of adoption and implementation of the policy? If adopted, can ways be found to administer a policy at reasonable costs and without unduly infringing on constitutional or traditional freedoms of individuals or institutions? If all these answers are "yes," will the proposed policy be effective in accomplishing its goals?

According to the economic efficiency guideline, society as a whole is most benefited when each resource is used in its highest and best use. In an ideal market economy this is approached when each activity bears its full social costs and benefits, including externalities; when all producers and consumers are completely informed; and when competition exists. We do not live in such an ideal world, however, and economic efficiency means that the costs of a policy should not outweigh its benefits and that the policy with the highest benefit-to-cost ratio is most likely to be efficient. In the area of waste management, the concept of efficiency is exemplified by the "polluter pays" principle. (9)

The equity guideline requires that the costs and benefits of using natural resources be fairly distributed. Equity also extends to the preservation of natural resources for future generations. The best way to achieve equity among generations, however, has yet to be decided. Participation refers to the right of citizens and their representatives to influence decisions that affect them and their heritage of nature's resources. Participation by affected citizens can help to achieve an equitable and acceptable resolution of conflicts.

To achieve ecological security for the human species the cycles that underlie life on this planet must be preserved. While not yet fully understood, this appears to require minimal disturbance of the air and water, control of persistent hazardous materials, preservation of plant and animal species, and preservation of unique or genetically rich ecosystems.

National security means maintenance of the integrity of the United States as an independent nation-state. There is disagreement over what constitutes independence and about how this goal is to be accomplished. In a world that features economic, political, ecological, and spiritual interdependence, the proper design of a materials policy to preserve national security is by no means clear.

Personal security, in the context of materials policy, pertains to the preservation of private property and the protection of individuals against undue risk of personal harm from the functioning of the materials system. It includes the right to just compensation for the sale of one's labor or property as well as the right to reasonable assurance against health hazards from improper production, use, or disposal of materials.

Options that allow for a variety of approaches to be used at the same time or at the same place are often more desirable than those that require using a single or uniform approach. In solid waste management, differing local circumstances may make certain solutions feasible in some places and unworkable in others. In some circumstances, a combination of approaches may work best. As issues in resource recovery, recycling, and reuse are brought to the national level, a diversity of approaches will allow for adaptation to local situations. This will also increase the chances that local experimentation may discover better approaches.

References

1. U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, Resource Recovery and Waste Reduction, Fourth Report to Congress, EPA Publication SW-600, Washington, D. C., U.S. GPO, 1977, p.4.
z. Ibid., p. xii.
3. U.S. Environmental Protection Agency, EPA Activities Under the Resource Conservation and Recovery Act of 1976, Report SW-663, February 1978, p,2.
4. Ibid., footnote 1, p. 18.
5. Ibid., footnote I, p. 17.
6. National Commission on Materials Policy, Material Needs and the Environment Today and Tomorrow: Final Report, June 1973,
7. Presidential Proclamation: Administration of Jimmy Carter, 1977. Nonfuel Minerals Policy; Announcement of a Cabinet-Level Interagency Study, Dec. 12, 1977.
8. Office of Technology Assessment, U.S. Congress, forthcoming report on Technical Options for Metals Conservation: Case Studies of Eight Selected Metals and Seven Selected Products, to be published in mid-1979.
9. Organization for Economic Cooperation and Development, The Polluter Pays Principle, OECD Publication 97-75-02-1, May 1975.

Chapter 3

The Marketability of Recovered Resources: Status and Policy Options

Contents

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The Marketability of Recovered Resources: Status and Policy Options

Introduction

Questions and Issues Addressed in This Chapter

Materials and energy recovered from municipal solid waste (MSW) compete for markets with secondary materials from other sources, as well as with primary or virgin materials, The objectives of this chapter are to determine: (i) whether markets would exist for recovered materials and energy from MSW if resource recovery were implemented widely; (ii) what factors, including governmental policies, influence the marketability of recovered resources: and (iii) what actions the Federal Government might reasonably take to remove barriers to marketing recovered resources or to stimulate their marketing.

This chapter examines markets for resources recovered in both centralized resource recovery plants and separate collection programs. The emphasis is on the current status of markets, but some attention is given to the marketability of resources over the next 15 years. Both the role and the status of specifications for recovered resources are discussed. The significance of transportation costs is examined, and the impact of railroad freight rate adjustments on the shipment and sale of recycled materials is assessed.

Factors That Influence the Marketability y of Recovered Resources

The marketability of a material or energy product recovered from MSW is influenced by a number of factors. These include: (i) the demand for such a product; (ii) its quality, including the degree to which it meets established specifications: (iii) the cost of shipping it to a customer; (iv) the price of an alternative material or energy source: and (v) any additional manufacturing costs due to using a recovered rather than a virgin product. Inadequacies or uncertainties in any of these factors can impair the marketability of a recovered resource.

Government policies may modify these influences, One example is that the demand for recovered materials may be influenced by Government subsidies to users of recycled materials or by taxes imposed on virgin materials. (See chapter 8.) Another is that freight rates for materials shipped by rail, which are established under ruIes set by the Interstate Commerce Commission [ICC). affect the net income available to recyclers.

The newness of many recovered materials and energy products coupled with the lack of accumulated experience with them makes potential industrial customers less ready to purchase them. The uncertainty about the technical performance of these products makes them an economic risk for potential buyers. This can only be overcome through the establishment of adequate performance or composition standards based on and accompanied by a history of satisfactory industrial use. Demonstration of the laboratory or pilot-scale technical feasibility of using recovered resources is often not sufficient to convince a plant manager who fears that his plant's ability to produce might be disrupted by raw materials or fuels of variable or substandard quality. This kind of concern appears throughout this study in connection with po-

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tential users of recovered paper, glass, ferrous metal, aluminum, and various forms of energy. The marketability of recovered resources is also uncertain because their prices and consumption fluctuate widely over time. This is particularly true for ferrous scrap, paper, and aluminum. Therefore, the revenues from resource recovery are uncertain. Contracts between sellers and buyers can be designed to aid in reducing these fluctuations, and Government actions have been suggested to help stabilize markets.

Quantities and Prices of Potentially Recoverable Resources

Recoverable Quantities Today

Tables 3 and 4 show breakdowns of the average composition of MSW by material and by product for 1975, the most recent year for which such data are available. These two breakdowns can be used to estimate the quantities of recoverable materials and energy in MSW using either the centralized resource recovery or the separate collection approach. Since neither is fully effective in recovering all the potentially recoverable waste, the actual amount recoverable per ton is less than the total content in the waste. Furthermore, since it is not likely that the entire Nation will adopt resource recovery, the amounts of materials and energy that are likely to be recovered nationwide are considerably less than the maximum potential.

Table 8 summarizes data on the materials recoverable from MSW by separating them from mixed wastes in centralized resource recovery plants. From a typical ton of MSW, as much as 140 pounds of iron and steel, 96 pounds of glass, 8 pounds of aluminum, and 2 pounds of other nonferrous metals are potentially recoverable using technology that has reached at least the pilot plant stage. Only the iron and steel are recoverable using commercially available technology. (See chapter 5.) If these materials were recovered from all the Nation's wastes, they could have supplied up to one-third of the Nation's glass needs and one-tenth of the aluminum and iron and steel usages in 1975.

Table 9 shows the amounts of alternative types of energy that could be recovered from an average ton of MSW. Dry fuel, or refuse-derived fuel (RDF), is obtained by separating raw waste into combustible and noncombustible fractions, as in Milwaukee, Wis., and Ames, Iowa. Steam is produced by waterwall incineration as in Saugus, Mass., or by small-scale incineration as in North Little Rock, Ark. Medium Btu gas is the product of the Union Carbide Purox process, which has been pilot tested. Electric power would be produced by using steam from a waterwall incinerator to drive a turbine-generator, or by burning RDF or gas in a conventional powerplant. (Factors to be considered in choosing the technology to be used and the form of energy produced are discussed in chapters 5 and 6.)

Table 8.—Materials Recoverable Using Centralized Resource Recovery

Material type	MSW content[a] (weight %)	Typical amount recoverable (lbs/ton of MSW)[b]	Maximum amount recoverable nationwide[c] (millions tons/yr)	Maximum recoverable as a percent of total material use in 1975[d]
Iron and steel	8.3	140	9.5	10
Glass	10.1	96		33
Aluminum	0.7	8	[illegible]	11
Other nonferrous metal	0.3	2	0.1	1.3

[a]From table 3.
[b]From RTC working paper One (I), considering typical recovery efficiencies.
[c]Based on 136 million tons of MSW in 1975 and typical amounts recoverable per ton.
[d]Based on total materials use in 1975 in million tons as follows: iron and steel, 951, glass, 200, aluminum, 46, and other nonferrous metals, 80

Table 9.—Alternative Energy Forms Recoverable From MSW Using Centralized Resource Recovery

Energy form	Typical amount recoverable per ton of MSW'
Dry fuel (RDF)	9.0 million Btub
Steam.	5,700 pounds[c]
Medium-Btu gas	6 million Btud
Electricity.	400 kWhC

'En~~gy forms are mU!Lla/ly exclusive.
bl,450 pounds of RDF at 6,200 Btu per pound Source RTC (1)
[c]Source RTC (1)
ds[source] Black and Veatch. and Franklin Associates, Lt'd (2)

The energy forms in table 9 represent alternative uses of the same MSW. If all the MSW were used to produce RDF, approximately 1.2 x 10'[5] Btu or 1.2 Quads* of energy would be produced annually. This is equivalent to about 1.7 percent of the total annual use of energy in recent years in the United States.

Separate collection programs could potentially recover a different fraction of the materials in MSW. Table 10 illustrates the MSW content of major source separable materials, along with estimates of the amounts recoverable per ton of waste and per year, if 50 percent of each material were recovered. This table also shows for each material the percentage of its total use nationwide that might be met by separately collected waste.

Current Prices of Recovered Resources

Table 11 summarizes OTA estimates of the ranges of delivered prices for recovered resources, based on various industry and Government sources. Since experience is limited, these prices, which are based for the most part on the judgment of informed persons, must be considered somewhat speculative. As shown in figure 3, the annually averaged prices for recovered paper, iron and steel, and aluminum fluctuate widely over time. Monthly swings are also dramatic from time to time. (The metallic commodities for which prices are shown in figure 3 are similar, but not identical, to those recoverable from MSW.)

*One Quad equals 10 Btu or 1.055 exajoules.

Table 11 also shows estimates of the potential revenues from each component of waste, based on recovery of the "typical amounts recoverable" taken from tables 8, 9, and 10. The reader is cautioned that prices and revenues at any particular plant and time may differ considerably from these. They are intended only to be illustrative of average conditions nationwide. The waste stream composition, which determines the amounts recoverable, depends on such local conditions as the amount and type of economic activity in a region, the economic status of its residents, the climate, seasonal changes in population, the nature of the beverage market, and the existence of source separation activities or beverage container deposit requirements.

Usually, long-term contracts with product purchasers are needed to sell recovered products and to obtain financing for centralized resource recovery plants. The prices of energy products may be set to follow the price of the fuel being displaced; as prices for such fuels as coal or oil rise, waste-derived energy becomes increasingly valuable. For certain kinds of energy products, assurance of uninterrupted supply to a purchaser may require installation of multiple processing lines, substantial fuel storage, or backup conventional energy systems. (See chapter 5.) In the absence of long-term contracts, material product revenues will generally parallel scrap prices, which fluctuate with short-term market requirements. Consequently, long-term contracts for the sale of recovered materials from MSW may be difficult to obtain. It is a common practice to arrange contracts to sell at no lower than a floor price, with a price above the floor set as a fraction of the prevailing market price of scrap,

Costs of shipping recovered products to market must be deducted from potential revenue estimates. Table 12 shows the impact of railroad freight charges on potential revenues from the sale of recovered materials. For ferrous metals, glass, newspapers, and solid aggregate, freight charges can be of the same order as the price that users are willing to pay for the recovered materials, even for

[a]From table 4.
[b]Assumes 50-percent participation in source separation. See chapter 4.
[c]Based on 136.1 million tons of MSW in 1975 and typical amounts recoverable at 50-percent participation.
[d]Based on total materials use as in footnote d, table 8.
[e]Includes newspaper, books, magazines, corrugated and office paper. See table 21 for details.
SOURCE: Office of Technology Assessment.

Table. 11.-Typical Prices and Gross Revenues for Recovered Resoumaa Delivered to Market

Resource type	Delivered Price		Potential gross revenueb (Won of MSW
From centralized resource recovery			
iron and steel	15-40	$/ton	1.05-2.80
Glass	1020	$/ton	0.48-0.98
Aluminurn		$/ton	
Other nonferous metal	I0000O	$/ton	0.10-020
Dry fuel (RDF)	0.501.00	$	4.50-9.00
Steam	1.50-3,00		8.55-17.10
Medium-Btu gas	1.50=3.00		9.00=18.00
Electricity	1.6=3.5		6.00=14.00
From source separation			
Newspaper	20=45	$/ton	0.88-1.46
Books and magazines	8-20	$/ton	0.08-0.23
Corrugated paper	15=45	$/ton	0.702.07
Office paper	75-120	$/ton	1.43-2.28
Steel containers	2040	$/ton	0.40-0.80
Glass containers	20-30	$/ton	0.92-1.38
Aluminum containers	300	$/ton	0.80

[a]Source: OTA estimates from various industry sources.
[b]Based on typical amounts recoverable. Must be reduced to amount for freight costs.
[c]Wholesale price%
‘Color sorted.

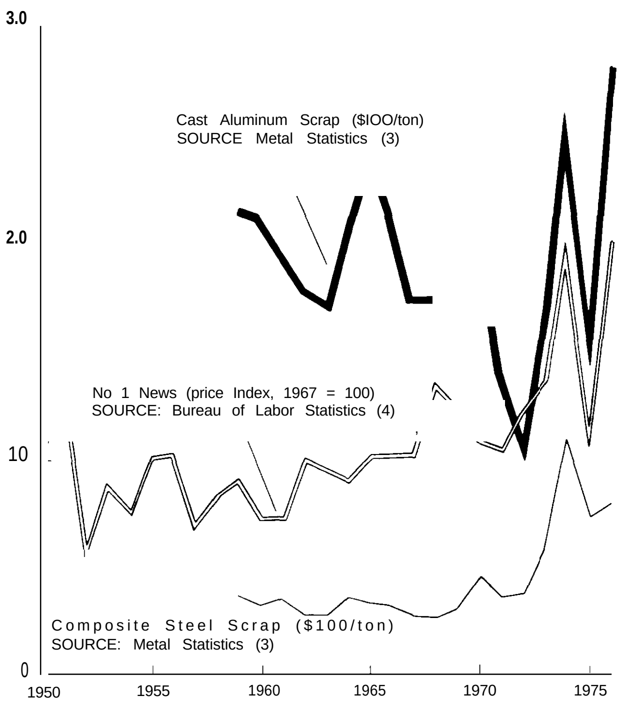
short hauls. Thus, the level at which freight rates are set influences whether some low-valued recovered products such as glass can be marketed at all.

Future Quantities of Recoverable Resources

By making a few simple assumptions about future population growth, per capita rates of waste generation, and the future composition of MSW, it is possible to project the total amounts of potentially recoverable materials and fuels in MSW on a nationwide basis. Resource Technology Corporation (RTC) made such projections for OTA in a report completed in 1976.(1)

RTC projected waste quantities for 1980 and 1995 using Bureau of the Census population projections, projections by the Environmental Protection Agency (EPA) of waste generation rates, and MSW composition the same as that in 1973. These gave total MSW

Figure 3.— Representative Annual Average Scrap Prices



generation rates of 175 million and **250** million tons per year in 1980 and 1995 respectively. These projections are summarized in table 13. In each case estimates of recoverable resources take into account the anticipated technical recovery efficiencies and assume that recovery is implemented throughout the Nation, The technology used in each case is centralized resource recovery, except that paper is assumed to be recovered by source separation.

Clearly, these estimates are sensitive to the assumptions used in making them. In particular, they are based on EPA estimates of per capita MSW generation rates of 4,28 pounds per day in 1980 and 5.27 in 1995 (as compared with 3.5 pounds per person per day in 1975). Many observers believe that these figures are too high in view of the recent rapid increases in the prices of materials generally, which will cause adoption of less materials-intensive products and lower discards. Furthermore, since it is unlikely that resource recovery will be implemented nationwide, the actual recovery of materials will be much lower than the potential shown in table 13.

Specifications for Recovered Resources

Specifications describe the origin, performance, or composition of a product. From a policy perspective specifications serve three important purposes. First, they serve as an accepted, uniform basis for claims of performance or quality of products. Such a basis helps the buyers and sellers of those products transact business with adequate knowledge of their characteristics. Second, they serve as a uniform basis for Government oversight of such transactions for the purpose of achieving certain policy goals, such as protection of consumer health and safety or protection of consumers against fraudulent claims of product quality. Third, specifications can be designed to inhibit the adoption of new or substitute products and to protect markets for existing ones. This section reviews the status of private and public efforts to establish specifications to guide the sale of recovered materials and energy.

Origin Specifications for Source Separated Materials*

As noted by Alter,(6) specifications for recycled materials have existed for many years. They have been developed by trade associations such as the National Association of Recycling Industries (NARI) and the Institute of Scrap Iron and Steel (ISIS). These standards reflect long established practices in the secondary materials industries and are based largely on the origin of each grade of recycled material.

Established origin specifications are generally appropriate and adequate to cover trade in paper products and metals recovered in

***This** section draws heavily on a paper by Alter.(6)

Table 12.—Effect of Transportation Costs on Potential Revenues From Recovered Resources ($/input ton)

Product	Average railroad freight rates for various transport distances ($/ton) Under 200 miles	200-400 miles	400-600 miles	Potential revenue from recovered resources at the market[b] ($/ton of MSW)	Potential net revenues at average prices for various transport distances ($/ton of MSW) Under 200 miles	200-400 miles	400-600 miles
Iron and-steel	6.67	10.39	75.93	1.93	1.46	1.20	0.81
Aluminum	8.91	14.35	19.07	1.20	1.16	1.14	1.12
Glass	9.19	11.82	14.29	0.72	0.28	0.15	0.03
Wastepaper	6.27	9.45	11.58	1.00c	0.84	0.76	0.71
Nonferrous	—	—	—	0.15	0.14d	0.14d	0.13~
Aggregate	—	—	—	0.05	0	0	0
Total	—	—	—	5.25	4.08	3.59	3.00

aSource: Moshman Associates, Working Paper Two (5) (Rates for October 1975.)
bBased on delivered prices in table 11 for materials recovered in centralized facilities
cBased on 50 percent recovery of newsprint only for sale at $40/ton
dAssumes freight rate same as for scrap aluminum

Table 13.— Projections of the Future Content of Recoverable Resources in MSW Nationwide

Materials

Waste component	Total amount-recoverable- (million tons) 1980	1995
Iron and steel	12	18
Glass	8	12
Aluminum	0.7	1.0
Paper (all types)	11a	15b
	16a	23b

Energy Alternatives

Energy form	Total amount recoverable 1980	1995
Dry fuel (RDF) (million tons)	130	180
Steam (billion pounds)	1,000	1,400
Medium-Btu gas (trillion Btu)	1,100	1,600
Electric power (billion kWh)	70	100

a-At a 16.5-percent recovery rate using source separation
bAt a 25-percent recovery rate using source separation
SOURCE RTC(1) Based on recovery in centralized resource recovery plants and on the amounts and composition of future waste noted in text

separate collection programs. For example, NARI has established standards for several grades of paper including "#2 Mixed Paper," "#I News," "Corrugated Containers," "#I Sorted White Ledger," and "Manilla Tabulating Cards,''(7) as well as for "Old Can Stock" (used aluminum cans).(8) ISIS maintains standards for "Shredded Tin Cans for Remelting.''(9)

There are no similar origin specifications for separately collected glass. Instead, glass manufacturers set standards for acceptance of glass cullet based on color (usually requiring color sorting) and on low levels of contamination by metals, organic matter, and refractory particles that do not melt in the glass furnace. Since stones can weaken a container considerably, it is quite reasonable that the bottle industries should wish to avoid them.

Composition Specifications for Materials From Centralized Resource Recovery

Origin specifications are unlikely to be satisfactory for materials recovered from mixed MSW in centralized resource recovery plants owing to the variability in the composition of waste and in the performance of the various recovery methods. * Committee E-38 of the American Society for Testing and Materials (ASTM) was established in 1974 to set con-

*The National Association of Recycling IndUStries (NARI) has published a special origin specification for "Mixed Nonferrous Metals From Resource Recovery Facilities.''(8) However, there has been no commercial trade in such a product to date. The Institute of Scrap iron and Steel (ISIS) has published an origin specification for "Incinerator Bundles" made up of tin can scrap that has been processed through a recognized garbage incinerator.(9)

sensus standards for products recovered from mixed MSW based on chemical composition rather than on origin. It is in the process of developing standards for the following products from mixed MSW: paper, steel, aluminum, glass, and RDF, Specifications are expected to be completed during 1979 for ferrous metal, aluminum, and glass "fines" recovered in the froth flotation process.(11)

ASTM Committee E-38 involves both potential producers and users of covered resources as well as those having a general interest in them. Through an elaborate process of discussion, analysis, and consensus-building, proposals for specifications will eventually be adopted. The intent is that specifications should be realistic in terms both of what can be recovered using available technology and of what purchasers can effectively use, One way to arrive at an effective compromise between producers and users that is being examined by the Committee is to define several grades for each recovered product.

In the absence of established specifications, the prices and specifications for products from a particular resource recovery project are adjusted to account for differences in product contamination and for quantities available for purchase. These prices are normally adjusted further as sufficient quantities of products are tested in commercial applications. Specifications are unlikely to be necessary for plants recovering steam or hot water. Specifications for medium-Btu gas or electric power will probably be negotiated among producers and users, based on established specifications for those products from conventional sources,

Government's Role in Setting Standards

Traditionally, development and adoption of product specifications in the United States have been largely voluntary activities of commercial interests. Consumers have played a small, or negligible, role in this process. The Government has been involved in several ways including: 1) participation by Government employees in voluntary standards organizations, 2) adoption by regulatory agencies of certain voluntary standards as mandatory, 3) support of research on testing methods and procedures, 4) development, promulgation, and enforcement of mandatory standards for specific purposes such as weights and measures, 5) establishment of unilateral standards for its own purchases of products, and 6) coordination of U.S. participation in international standard-setting bodies.

Under current programs and plans, most material and energy products recovered from MSW by source separation or by centralized resource recovery are destined first for sale to commercial firms for further processing. Thus, consumer protection goals of product specifications are of little direct interest in this context. Attention has been addressed therefore, to the role of specifications in facilitating commercial transactions. *

Pursuant to section 5002 of the Resource Conservation and Recovery Act of 1976, the National Bureau of Standards (NBS) was made responsible for publication by October 21, 1978, of guidelines for the development of specifications for the classification of recovered materials. The Bureau is to work in conjunction with the national voluntary standards organizations. However, no funds have been appropriated to NBS for this work.

EPA has supported the development of consensus standards through a contract to ASTM for the activities of Committee E-38 on Resource Recovery.

In view of the current existence or development of specifications for recovered products, there appears to be no need for additional Federal involvement in supporting, establishing, or enforcing specifications for recovered resources. Activities currently underway in the private and public sectors appear to be addressing those areas in which current specifications or their absence are

*Products recovered for reuse, such as beverage containers, and newspapers recovered to produce cellulosic thermal insulation do present issues of consumer protection.

barriers to recycling. Until further experience with centralized resource recovery is accumulated, Government efforts to accelerate standards development are probably unnecessary.

The Nature of Markets for Recovered Resources

Materials Markets

FERROUS METALS

Ferrous metals include iron and steel scrap recovered as tin cans in separate collection programs, as magnetic materials from front-end separation in resource recovery plants producing RDF or pyrolysis gas, or as magnetic materials recovered from incinerator ash, Principal markets for these products are tin recovery, copper precipitation, the ferroalloy and steel remelt industries, and foundries producing gray and ductile iron.

Tin cans, if not crushed, contain sufficient tin to be of economic interest to detinning plants for tin recovery. They can also be sacrificed to recover copper in copper precipitation. The steel industry will use cans and other nonincinerated ferrous metals if they are clean, crushed, and baled to sufficient density. This requirement, however, is incompatible with the needs of detinners. Contamination by nonferrous metals and organic substances must be low for uses requiring remelting.

Markets for incinerated ferrous metals are limited both because incineration alloys tin and copper with the steel and because it oxidizes and contaminates it with ash and molten glass. This contamination renders incinerated ferrous metal unacceptable to detinners. The ferroalloy industry can use clean, shredded incinerated ferrous. Foundries are also potential users. Incinerated ferrous recovered from mixed MSW has not been commercially processed for recycling in the United States.

ALUMINUM

Historically, the primary aluminum industry has used scrap generated within the plant and has used scrap ingots purchased from the secondary aluminum industry. More recently, the primary aluminum industry has been purchasing clean aluminum beverage containers from separate collection programs. These are remelted and used in the production of various aluminum products. Contaminants in aluminum recovered from mixed MSW such as copper, magnesium, silicon, glass, and iron may limit its use for beverage containers, but it may be possible to use such waste aluminum in lower grade products such as castings. There has not as yet been any commercial experience using aluminum recovered from mixed MSW. It is anticipated that the aluminum industry will have sufficient capacity to use all of the aluminum reclaimable from MSW in the foreseeable future.

MIXED NONFERROUS METALS

Mixed nonferrous metals recoverable through front-end separation in RDF or pyrolysis plants would include copper, zinc, lead, and nonmagnetic stainless steel. This waste portion may be of interest to the scrap processors who currently process similar material reclaimed in some automobile shredders. If it can be cleaned and separated at reasonable cost, it would bring a price of perhaps $100 to $200 per ton. Since such material has only been reclaimed in very small quantities in research facilities, its marketability cannot be assessed.

GLASS

Nearly all of the glass in MSW comes from containers, including beverage bottles. It can be recovered in several forms: as color-mixed or color-sorted glass from separate collection programs or from nonreturnable bottles recovered through beverage container deposit programs: as color-sorted broken glass, or "cullet," recovered using optical sorting techniques in centralized resource recovery plants; or as color-mixed broken glass, or "fines," recovered using the froth flotation process in centralized plants,

Recovered glass can be used to make new bottles if it is clean and free of refractory particles, or "stones. " Color-sorting is required to make new clear or "flint" glass. Color-mixed recovered glass can be used as part of the raw materials in the manufacture of green or brown bottles,

Lower quality uses for waste glass have been tried, such as for floor paving, for highway and construction aggregate, for wallboard, and for insulation. While these are all technically successful uses for recovered glass, it must compete with very inexpensive alternatives such as sand and gravel, Therefore, its marketability is expected to be limited,

Recently, bottle manufacturers have developed greater interest in using recovered glass for three reasons.(12) First, in glass manufacture less energy is required to use waste glass than to use virgin raw materials because the melting temperature of the waste glass is lower, This has proven of interest to the industry, which uses a large amount of natural gas as a fuel. Second, air pollution from glassmaking is considerably reduced when waste glass is used as a raw material, allowing some plants to meet particulate emission standards without costly controls. Third, experience has begun to accumulate in using over 50 percent cullet as raw material without operating problems, whereas previous experience had suggested an upper limit of 15 to zo percent. The biggest problem in using recovered glass remains keeping metallic and refractory contamination very low,

only a very small portion of the potentially recoverable glass is currently being recycled nationwide, but activity is rapidly growing, especially in the Northeast. The Northeast region has a large number of bottle production plants, great interest in air pollution control and energy conservation, three States with beverage container deposit laws (Vermont, Maine, and Connecticut), and a considerable number of municipal separate collection programs. All of these factors work to the advantage of glass recycling. Data in a recent EPA report suggest that in the Northeast on the order of 50,000 to 100,000 tons of glass is being recycled each year from postconsumer sources.

PAPER

For many years the United States has recycled a significant part of all postconsumer wastepaper. For 1978 the American Paper Institute estimates that the equivalent of 24 percent of all paper and paperboard products were collected—a total of 16.7 million tons.(14) Of this amount, 1.6 million tons were exported, and 14.8 million tons were used to produce new paper and paperboard products. The widely discussed insulation market used only 0.15 million tons, and other uses were 0.14 million tons. *

Relatively recently commercial processes have been developed that are capable of producing new newsprint from 100 percent recycled newspapers. This makes it possible to recycle to a higher order of use than the older, established uses of waste newspaper for construction paper, paperboard, and boxes. The newsprint market is more stable than the older markets, which tend to fluctuate with the business cycle. As the recycled newsprint market grows, therefore, it should serve to stabilize the overall markets for recovered paper. The Garden State Paper Company of Richmond, Va., currently operates newsprint recycling mills in Garfield, N. J.; Pomona, Calif.; Alsip, Ill.; and Dublin, Ga. These have a combined capacity to consume an average of 700,000 tons of waste newspaper per year.(15) Two other firms use lesser amounts as part of their raw material inputs, totaling about 100,000 tons per year.

Separate collection programs (commercial, industrial, and residential) are the only sig-

*See chapter 2 regarding the Emergency Interim Consumer Product Safety Standard Act of 1978 that was passed in response to concern for the fire hazards of inadequately treated cellulosic insulation made from old newspapers.

nificant source of postconsumer recovered paper today. No commercially available centralized resource recovery process can recover paper fiber suitable for recycling as paper. All existing methods treat the paper in waste as a part of its fuel content, except for a small amount of handpicking of bundled paper for recycling from the feed conveyors at the Milwaukee and New Orleans resource recovery plants. (See chapter 5.)

The fact that centralized resource recovery plants view wastepaper as fuel and that paper recyclers view it as a raw material is a potential source of conflict among these interests. The energy and economic implications of this tradeoff are discussed in chapter 4, and the local institutional problems it creates for implementing resource recovery are discussed in chapter 7.

AGGREGATE

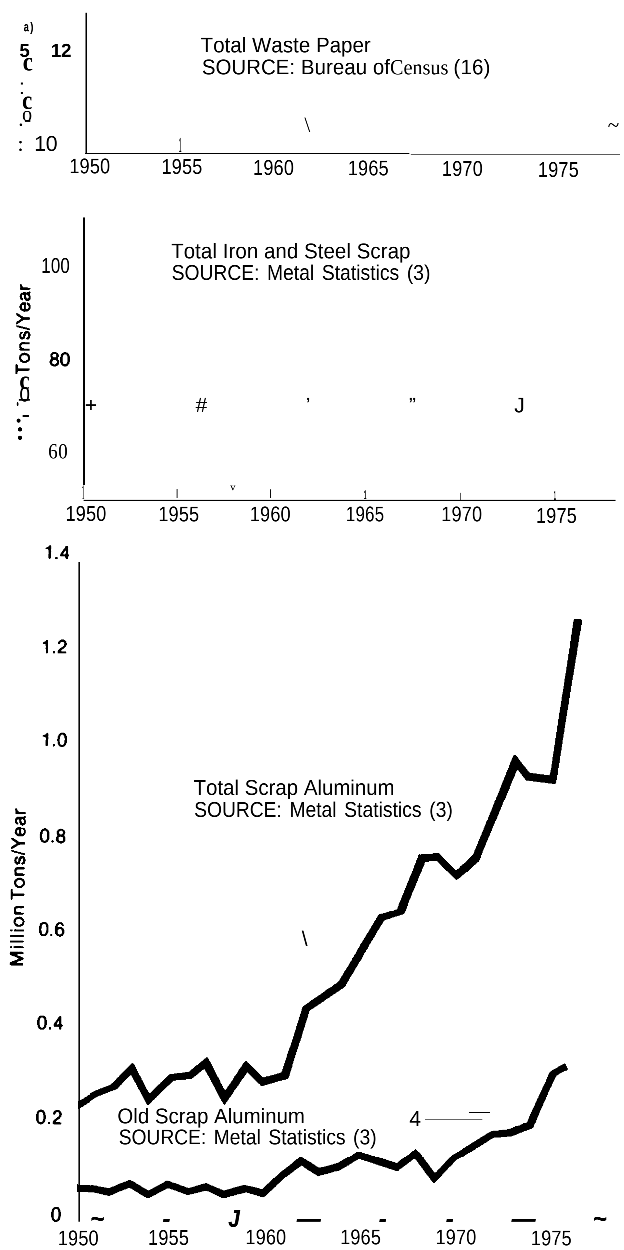
Aggregate derived from solid wastes consists primarily of small particles of glass, stones, bones, metal, ceramics, and plastics. It might be used as a sand or gravel substitute in road construction as well as in other concrete applications, and as a construction material in wall panels, terrazzo flooring, and insulation. However, aggregate from MSW has not been used on a commercial basis in the United States. If a resource recovery facility operator could sell this material at cost or even give it away, he could at least save the cost of its disposal.

Impacts of Recovered Materials on Established Secondary Materials Markets

Widespread adoption of resource recovery and recycling programs may affect the already volatile markets in which secondary materials are traded. The prices and quantities of secondary materials traded, particularly of postconsumer and other obsolete scrap, vary widely and change frequently. Figures 3 and 4 support this fact with historical data on annual average prices and annual quantities traded for scrap paper, aluminum, and iron and steel.

Resource recovery and recycling, if successful, will provide a steady stream of prod-

Figure 4.—Representative Annual Scrap Consumption



ucts that producers will need to sell immediately and that might undercut the sales and prices of similar secondary materials from other sources. Table 14 compares the total materials content of MSW to historical levels of trade in recent years in the most nearly comparable established scrap markets. The ferrous metal content of MSW is small compared to existing trade levels and would be unlikely to seriously disturb the established market on a nationwide basis. For aluminum and paper, on the other hand, significant activity in scrap recovery from MSW would be a large addition to existing trade levels. Current trade in recovered glass is so small that the glass content of MSW is nearly 500 times larger. In this case, however, the outcome is development of a new market rather than disruption of an old one.

In examining the potential impact on established markets it is necessary to distinguish between short-run and long-run phenomena. The short-run prices of secondary materials are largely independent of their supply and are heavily dependent on the demand for finished materials such as boxboard and steel, In times of high economic activity, materials producers will pay high prices for scrap in order to meet customer demands. Under such conditions, secondary materials suppliers, receiving high prices, can afford both to dip more deeply into scrap inventories and to bear shipping charges over longer distances. In the long run, however, secondary materials prices follow a more steady trend.

Widespread adoption of centralized resource recovery would require construction of capital equipment over a period of several years. It can only make a large contribution to the supply of recovered materials in the long run. The resulting steady flow of secondary materials from MSW will be likely to find entirely new uses or to replace virgin raw materials rather than other secondary materials.

Table 14.—A Comparison of Materials Content of MSW to Existing Scrap Markets

Secondary material type: MSW component	Secondary material type: Counterpart scrap material traded[b]	MSW content as percent of counterpart scrap material traded
Ferrous metal	Total iron & steel (17)	11
	Purchased iron & steel (17)	21
Aluminum	Total aluminum (3)	104
	Old scrap aluminum (3)	435
Total paper	Total paper (16)	380
Newspaper	Newspaper (16)	425
Glass	Glass cullet	50,000[c]

[a]Based on 1975 gross discards In (18)
[b]Based on average of trade In 1973, 1974, and 1975 Data from Sources In. dicated
[c]Estimate based on data in (5)

Energy Markets

REFUSE-DERIVED FUEL

Refuse-derived fuel can be consumed as a supplementary fuel in coal-fired electric powerplants and industrial boilers, in Portland cement plants, in sludge incinerators, and in new and existing boilers designed or modified to use RDF exclusively. Not all the potentially available RDF is likely to be consumed by utilities because (i) most of the coal-burning electric powerplants are located in the eastern part of the country, (ii) long distance transportation is prohibitively expensive, and (iii) utilities have been reluctant to use RDF for reasons discussed in chapter 7. However, current national energy policy expressed in the Powerplant and Industrial Fuel Use Act of 1978, which emphasizes coal use, may provide a strong boost to the combustion of mixed RDF and coal and of RDF alone.

Industrial solid-fuel-fired boilers might consume RDF alone or as a supplemental fuel to coal, wood waste, bagasse, industrial waste, paper, or agricultural wastes to produce steam for onsite industrial processing and heating. However, many industrial boilers have significant daily and seasonal variations in fuel demand that may be a problem for large-scale RDF use. RDF has been used experimentally to provide part of the heat to produce cement, The allowable ratio of RDF to primary fuel depends on the kiln temperature, RDF ash chemistry, and method of injection of RDF into the cement kiln. Experiments are also underway on RDF as auxiliary fuel in sewage sludge incinerators.

Refined dry solid fuel produced by Combustion Equipment Associates is made by drying, chemical treatment, and milling of coarse RDF to produce a powdered fuel called ECO-FUEL 11’. Larger quantities of this fuel than of RDF can be used as supplementary fuel because of its lower ash and moisture content and its greater heating value.

Theoretically, utility and industrial boilers could use all the RDF that could be produced from MSW in the United States. However, economic and institutional barriers discussed in chapters 5 and 6 will keep use well below the total potential.

STEAM

Steam produced in waterwall and modular incinerators can be used for space heating and cooling, process heating, and power-producing applications. It is an established commodity that can be bought and sold with minimal risk to buyers and sellers. However, steam cannot be stored in large quantities or shipped economically much further than about 1 mile. Thus, careful attention must be paid to matching steam producers and consumers.

ELECTRIC POWER

Electric power can be produced by incineration of waste to produce steam and then electric power in resource recovery plants. Since electricity is used universally and can be transmitted easily over long distances, it is a highly marketable product. The sale of electric power from solid waste facilities is not expected to be limited by the size of the potential market, but by external constraints such as reliability and regulatory requirements, prices of competing sources of electric power, price-setting considerations, and other legal and institutional constraints.

MEDIUM-BTU GAS FROM PYROLYSIS

With a heating value above 300 Btu per standard cubic foot, medium-Btu gas is usable in virtually any boiler or furnace equipped for natural gas, fuel oil, diesel oil, or solid fuel. The capacity to consume medium-Btu gas, therefore, is estimated to be many times greater than the maximum quantity of gas that could be derived from the total solid waste produced nationwide. For example, if all the Nation’s MSW could be converted to medium-Btu gas, it would produce 1.1 Quads compared with a total energy use of about 70 Quads. Because this gas is not economically storable or transportable over long distances, it has its maximum potential where resource recovery plants are located near consumers. Also. it is limited to nonresidential users (two-thirds of the total gas market) because it contains large amounts of hazardous carbon monoxide.

LOW-BTU GAS FROM PYROLYSIS

Low-Btu gas has a heating value below 200 Btu per standard cubic foot and, like medium-Btu gas, contains significant quantities of carbon monoxide. Furthermore, a considerable portion of the total energy content of hot low-Btu gas from pyrolysis is represented by its high temperature, which dissipates in transmission. Thus, it may be suitable only for onsite production of steam or electric power.

LIQUID FUEL FROM PYROLYSIS

Based on experiments, this fuel can be used in furnaces designed to burn No. 6 fuel oil, with minor modifications. It may also be used as a supplement to coal, wood waste, or other solid fuel provided that modifications are made to store, handle, and transfer the liquid fuel to the combustion zone. The total potential pyrolysis oil from MSW would be only a small fraction of current oil imports, so its marketability y is very great.

Impact of Recovered Energy on Established Energy Markets

Recovered energy has the potential to contribute a maximum of 1.9 percent of the Nation's current energy use. (See chapter 5.) This energy can be recovered as solid fuel, steam, electric power, gas, or liquid fuel, depending on local markets. Because of the Nation's continued demand for energy in the face of supply problems, recovered energy cannot have an adverse effect on markets for established energy sources in the foreseeable future.

Future Markets for Recovered Materials and Energy

Earlier in this chapter, RTC'S projections of the maximum resources recoverable from MSW in the years 1980 and 1995 were reported. RTC also projected the size of the potential future markets for these resources on both the national and multistate regional levels. [See Working Paper No. 1.[1))

Potential consumers were identified for 1980 on an individual plant basis in each State for each product. Both existing capacity and anticipated plant expansions as of the summer of 1976 were included. No attempt was made to determine whether the identified customers would be willing or able to use the potentially available resources at their anticipated prices and qualities. RTC also did not examine whether future events might stimulate building additional capacity to use recovered resources,

RTC'S analysis indicates that in 1980 there would be markets for essentially all of the following potentially recoverable resources: iron and steel, aluminum, other mixed nonferrous metals, medium-Btu gas, and electric power. There will also be good future markets for substantial percentages of other potentially recoverable products such as: glass, 53 percent: paper, 81 percent: RDF and steam, 64 percent: low-Btu gas. 81 percent; and liquid fuel, 90 percent. Potential markets will exist for the small fraction of the available resources that will actually be recovered in 1980, However, it is not possible with the available data to estimate what fraction of the potential markets could become actual markets at expected product prices and qualities. Neither can one say how much the construction of additional capacity to use recovered resources might be stimulated by their future availability.

Government Policy and Market Development for Recovered Resources

The Federal Government could consider several policies that would help convert potential markets for recovered resources to actual markets, or that would create new markets altogether. In this section three such policies are briefly considered: Federal procurement, Federal stockpiling, and Federal support of research and development (R&D) on potential uses of recovered resources. (Policies that directly stimulate the supply of recovered resources are discussed in chapters 4, 5, and 6: and policies that directly affect the competition between virgin and recovered resources are discussed in chapter 8.)

FEDERAL PROCUREMENT OF RECOVERED RESOURCES

Mandated Federal procurement of recovered resources or of products made from them is intended to develop markets by creating at least one large and willing customer, the Federal Government. This policy would stimulate resource recovery by helping to ensure revenues. Mandated procurement would also speed the development of performance specifications, which would be needed as a basis for Government purchasing. At a minimum, Federal procurement policy should remove explicit barriers in existing specifications that hamper the use of recovered resources.

However, Federal procurement is a popular tool for implementing a host of other policy goals such as preservation of competition, strengthening small business, preserving regional economic balance, encouraging minority business, and protecting worker health and safety. Thus, the real potential of the procurement approach to stimulate recycling may be limited.

Section 6002 of the Resource Conservation and Recovery Act of 1976 (RCRA) provides for Federal procurement of ". . . items composed of the highest percentage of recovered materials practicable consistent with maintaining a satisfactory level of competition. " In November 1978 the General Services Administration revised its procurement regulations to comply with this part of RCRA. (41 CFR 1-1.25) It is interesting that this part of RCRA explicitly recognizes only the preservation of competition as an alternative goal of Federal procurement. Kovacs and Klucsik (19) have argued that the intent of this clause was only to recognize the importance of competition among various purveyors of recycled materials. But, this appears to be a narrow interpretation of the intent to acknowledge the other goals of existing procurement policy.

FEDERAL STOCKPILE FOR RECOVERED RESOURCES

In view of the uncertain nature of markets for secondary materials, reflected in the price and quantity swings of figures 3 and 4, the Federal Government could consider establishing an economic stockpile to stabilize these markets. A stockpile would purchase recovered materials from resource recovery projects when prices and quantities purchased are low and sell when prices and quantities are high. By acting in such a countercyclical manner, the Government would help raise low prices and reduce high ones. *

Stockpiled products could include recovered iron and steel, aluminum, and paper. Early experience with recovered glass markets does not suggest that this material will face the same swings that the metals and paper face. This is largely because the demand for glass containers is not nearly as sensitive to general economic conditions as it is for metals and paper.

For recovered iron and steel, a stockpile would have to cope with the existing trade in scrap iron and steel, which is considerably greater than any potential trade in these commodities from MSW. (See table 14.) Therefore, such a stockpile could be very costly and it would have greater impacts on the established ferrous scrap industry than on the resource recovery industry.

A stockpile for aluminum recovered from MSW might be reasonably effective in stabilizing its market, because a good portion of all old scrap aluminum already comes from MSW. Furthermore, scrap aluminum has a high value per ton and the physical costs of handling it would be relatively low. On the other hand, a stable market for aluminum, per se, would be insufficient to stimulate resource recovery because aluminum provides only a small portion of the potential revenues (See table 11.) In addition, prices paid by the aluminum companies to collectors of postconsumer aluminum cans have steadily grown from 15 to 20 cents per pound over the last several years. Thus aluminum recovered by source separation does not appear to be affected by market variations.

A stockpile for recovered paper faces yet another set of problems. First, recovered paper has a relatively low value both per ton and per cubic foot. It must be kept dry and is susceptible to rot and fire. Therefore, the costs of storing wastepaper are very high relative to the costs of storing metals. Furthermore, the fluctuation in the price of wastepaper tends to occur over fairly long periods, with 6 or 7 years between major peaks. (See figure 3,) The combination of high storage costs and storage times as long as 3 or 4 years makes a wastepaper stockpile economically unattractive.

This brief and nonquantitative analysis suggests that stockpiles for recovered re-

*In an earlier report, OTA examined alternative economic stockpiling policies for materials in the United States. Resource recovery and recycling were not among the objectives of that report, but it provides a broad view of issues, problems, and opportunities associated with economic stockpiles in general.

sources are unnecessary, overly expensive, or inadequate. Further research on the performance of economic stockpiles for recovered resources is needed to clarify the issues raised here.

FEDERAL SUPPORT OF R&D IN USES OF RECOVERED RESOURCES

Federal funds have supported R&D to find new uses or to improve old uses for recovered resources and such support could be continued, Federal R&D support is probably not necessary for materials recovered by source separation, nor for such energy products as steam, electric power, and gas; all of which can enter established markets. Likewise ferrous metals and aluminum recovered in centralized systems should be readily usable. However, additional R&D may be necessary to find or improve uses for RDF, glass, mixed nonferrous metals, solid aggregate, and incinerated ferrous metals from centralized resource recovery.

The need for additional R&D, however, is insufficient by itself to justify Federal support for it; there also should be a demonstration of market failures that lead to inadequate private support, (See chapters 5 and 7 for elaboration of this point.) In the case of resource recovery, such market failures include: (i) the lack of a capability to carry out R&D on the part of resource recovery operators who are largely public agencies or contractors, (ii) the lack of market incentives for potential users of RDF, especially electric utilities, to research its performance, and (iii) the disaggregated nature of potential users of small amounts of recovered nonferrous metals, glass, and incinerated ferrous metals.

Subtitle H of RCRA, which authorizes research, development, demonstration, and information activities does not include R&D on the uses of recovered resources. However, the Bureau of Mines has supported such work in the past, and EPA has supported demonstration projects that have examined the use, as well as the production, of RDF, Also, under section 5003 of RCRA the Secretary of Commerce has broad authority to "encourage the development of new uses for recovered materials, ' presumably including R&D funding.

Railroad Freight Rates and Markets for Recovered Materials*

The Impact of Freight Rates on Resource Recovery Revenues

Shipping charges to market can substantially affect the potential revenues from resource recovery projects as well as the competition between virgin and recovered materials. Table 12 shows estimates of the impact of railroad freight charges on potential revenues from recovered resources for

*There is an extensive history of debate and analysis on the freight rates for secondary materials, and on the equity and efficiency of regulated freight rates in general. Under section 204[a)(1) of the Railroad Revitalization and Reform Act of 1976, the Interstate Commerce Commission (ICC) was ordered by Congress to: "conduct an investigation of (A) the rate structure for the transportation, by common carriers by railroad subject to part I of the Interstate Commerce Act, of recyclable or recycled materials and competing virgin natural resource materials, and (B) the manner in which such rate structure has been affected by successive general rate increases approved by the Commission for such common carriers by railroad. " The Commission's findings and decisions in this matter were rendered on February 1, 1977, in Ex Parte 319, "Investigations of Freight Rates for the Transportation of Recyclable or Recycled Commodities."' It found discrimination in only a few minor cases. The Commission's procedures and decisions were challenged in the U.S, Court of Appeals for the District of Columbia by the National Association of Recycling Industries and the Institute of Scrap Iron and Steel. [No. 77-1187, 77-1192, 77-1 193.] The Court found the ICC's procedures unacceptable in view' of the Act's requirements and on August 2, 1978, ordered the ICC to carry out a new investigation. On April 16, 1979, the ICC rendered its decision under the new investigation, Ex Parte 319 (Sub-No. 1), "Further Investigation of Freight Rates for the Transportation of Recyclable or Recycled Materials. " The ICC found discrimination against a number of scrap commodities, although not in all areas of the country. It ordered that such discrimination be eliminated within 90 days. In various regions discrimination was found to be significant against ferrous scrap, aluminum scrap, and wastepaper, among others. No findings with respect to waste glass were presented.

various shipping distances. For transport distances of 200 to 400 miles, freight rates in effect in 1975 (the latest year for which comprehensive data are available) would have reduced revenues from iron and steel by 38 percent, for aluminum by 5 percent, for glass by 79 percent, and for paper by 24 percent. Thus, the revenue reduction for all but aluminum is significant and for glass it is prohibitive.

Two fundamental economic facts are reflected in these data. First, typical freight charges for shipping a ton of waste material over a distance of 200 to 400 miles in October 1975 ranged from $9.45 for paper to $14.35 for aluminum. (See table 12.) (At a typical 7-percent increase per year this range would be about $12 to $18 per ton in 1979.) The second fact is that the prices users are willing to pay for these materials are generally in the range of $20 to $45 per ton, except for $300 per ton for aluminum. (See table 11.) It would appear, therefore, that there is little room to absorb shipping costs in these prices, except for aluminum. Thus, resource recovery plants must be located close to both producers of waste and consumers of their outputs.

The same is true for recovered energy in solid form, such as RDF, that must be shipped by rail or truck. Typically, RDF has a fuel value equivalent to $5 to $10 per ton. Clearly, it cannot bear a freight charge of the order of $10 Per ton or more and must be consumed near the point of production. Oil, gas, and electric energy from MSW could be shipped further than RDF due to the better economics of pipelines and electricity transmission. Steam can only be shipped a mile or so by pipeline and still retain appreciable economic value.

Proponents of recycling have asserted that freight rates for recovered resources are too high. Even if they are double what they should be (an unlikely possibility—see the following section) however, and were cut in half, they would still place an important limitation on the location of resource recovery with respect to product markets.

Freight Rates and the Demand for Recovered Materials

The demand for transportation services for any commodity is a function of the demand for the commodity and of the contribution of transportation costs to the price of the commodity. It is instructive to consider the elasticity of demand (a measure of the sensitivity of demand to price) for transportation services for a commodity. It can be shown (21) that Et, which is defined as the percentage change in the demand for transportation of a commodity caused by a l-percent change in the price of transportation, is related to the elasticity of demand for the commodity, EC; the price of transportation, P_t; and the delivered price of the commodity, PC, according to the following equation:

$$E_t = \left[\frac{P_t}{P_c}\right] E_c$$

In this equation, E_c represen s the percentage change in demand for the commodity caused by a l-percent change in its price. Note that in general a higher priced commodity has a lower elasticity of transportation demand for a given transportation price P_t and a given commodity elasticity of demand. That is, an increase in freight rates causes less drop in demand for an expensive commodity than for a cheap one. Hence, an expensive commodity can "bear" a higher freight rate, In the short run, E_c is small for scrap commodities; that is, their demand is not very sensitive to their price. *

Literature estimates of the price elasticity of demand for scrap were collected by Moshman Associates.** These are summarized in table 15 along with data on prices and with

*The analyses in this section are based on short-run elasticities of demand for scrap. Short-run elasticities of scrap demand are low; that is, demand is not very sensitive to price. While not much information is available on long-run elasticities of demand for scrap, it appears that scrap demand may be more responsive to price over long periods of time.(22)

**Elasticities of scrap demand are difficult to estimate and are subject to considerable error. The data and methods available for estimating such elasticities are not of good quality.

Table 15.-Estimated Scrap and Transport Demand Elasticities in the Short Run*

Material	Demand elasticity E_c	Freight rate Pt ($/ton)	Delivered price Pc (Wton)	Transport demand elasticity
Ferrous scrap.	-0.12 to -0.59	8.65	64.04	-0.016 to -0.08
Aluminum scrap	-0.03	23.82	345.60	-0.002
Glass cullet	-0.5 to -0.75	18.60	30.00	-0.31 to -0.47
Wastepaper	-0.16	12.91	28.73	-0.07

"SOURCE: Moshman Associates(5).

elasticities of transport demand derived from them. The elasticity of transport demand is extremely small for ferrous scrap (iron and steel), for aluminum scrap, and for wastepaper. It is larger for glass cullet.

The change in freight shipments in response to a change in freight rates can be estimated using the following equation, based on the definition of elasticity of demand:

$$\left(\begin{array}{c}\text{percent change}\\ \text{in shipments}\end{array}\right) = \left(\begin{array}{c}\text{elasticity of}\\ \text{transport demand}\end{array}\right)\left(\begin{array}{c}\text{percent change}\\ \text{In freight rates}\end{array}\right)$$

With this equation, one can estimate the impact of freight rate adjustments on shipments of scrap materials by rail, once a determination of the appropriate adjustment has been made. This equation cannot be used to assess the effect of railroad freight rate changes on shifts to or from other modes of transportation.

Railroad revenues from shipment of a commodity are also affected by a change in freight rate. Suppose that a rate change were to occur for a commodity. Railroads would experience revenue changes due not only to the gain or loss of traffic, but also to the gain or loss of revenue per unit of unaffected traffic. Since all the scrap transport demand elasticities lie between O and –I, it can be shown that freight rate reductions would lead to revenue decreases, despite increased traffic. Similarly, rate increases would lead to increased revenues despite traffic losses.

A Comparison of Freight Rates for Virgin and Secondary Materials

ISSUES AND APPROACH

Shipping most secondary materials from processors to consumers represents a significant fraction of the total cost to the consumer. Thus they affect the consumer's decision about whether to purchase secondary or virgin materials. Some observers have argued that not only are these shipping costs high, but they are excessively high when compared to freight rates charged for other commodities; in particular for the corresponding virgin materials. If it were true that freight rates discriminate against secondary materials, then such rates might be adjusted by Congress as a matter of policy. To illuminate this issue, three major questions were examined: (1) the basis for railroad freight rates, (2) whether railroad freight rates discriminate against secondary materials, and (3) how adjustment of railroad freight rates might affect the marketability of secondary materials and the railroad revenues.

Moshman Associates, under contract to OTA, examined four pairs of corresponding virgin and secondary materials used in four different industries: iron ore/iron and steel scrap to make steel; bauxite/aluminum scrap to make aluminum ingot; pulpwood/wastepaper to make paperboard; and glass sand/cullet to make glass containers. Freight rates for MSW and RDF were also examined, although they have no virgin counterparts. Em-

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phasis was placed on rates for shipment by rail. The estimates of the impact of freight rate adjustments on materiaI shipments were based on short-run elasticities of demand. No attempt was made to account for long-run shifts as new kinds of capital equipment are installed by potential secondary material consumers. The data for the analysis were based on submissions by the railroads in Ex Parte 319.(23) The detailed results are in Working Paper Number Two.(5)

THEORETICAL BASES FOR RAILROAD FREIGHT RATES

Freight rates for common carrier, interstate shipment of goods by railroad are overseen by ICC under the Interstate Commerce Act of 1887, as amended. Rates are set in order to achieve several goals, including (i) a reasonable rate of return on a railroad's investments, (ii) avoidance of undue discrimination among locations and among individual shippers of the same commodity, and (iii) other goals in the national interest such as support of depressed essential industries, One fundamental problem in ratemaking is to cover both the variable costs and the large fixed costs of operation. A major policy question is how to allocate the fixed costs among various freight services,

The Interstate Commerce Act prohibits discrimination among locations and shippers; i.e., charging different rates for shipping the same product for different customers or charging grossly different rates for shipments of the same product between two sets of locations by different routes. However, the Act does allow discrimination among products on a value-of-service basis, *

The goals of ratesetting for secondary materials can be approached by any of five rationales for ratemaking including: (i] marginal cost, (ii) variable cost, (iii) fully allocated cost, (iv) value of service, and (v) equivalency. Marginal cost pricing requires that each rate be set equal to the additional, or marginal, cost of providing the transportation service, adjusted as necessary to ensure railroads a reasonable rate of return in the face of declining average costs. According to the marginal cost pricing model, if rates are fair, the ratios of freight rates to marginal costs should be approximately equal. Actual implementation of this principle requires far more detailed cost information than railroad accounting systems can provide and is further complicated by the fact that many costs cannot be unambiguously assigned to particular services.

Fully allocated costing requires fair rates to be set equal to long-run average costs, including a return on investment. Like marginal cost pricing, however, this approach requires more data than are usually available, as well as arbitrary allocations of costs among services. Friedlaender notes other technical problems with ratesetting in this model.(27)

Variable costing allows fair rates to be set equal to the short-run average variable costs associated with accepting an additional unit of traffic, This method is based on cost factors that are reasonably well-defined as compared with marginal or allocated costs.

Rates based on value-of-service recognize that higher valued commodities can bear a higher freight rate than those of lesser value. The value-of-service concept tends toward a system of rates that are directly proportional

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*As in other established areas of economic regulation, railroad freight rate regulation is beset with a complex mix of legal and economic rationales and definitions, based heavily on an obsolete framework developed when railroads faced lit tle competition from other transportation modes and when rate wars threatened both the industry and its customers, (24,25,26) The analysiss i n this report does not take t ha t framework as fixed, but assumes that Congress could make policy decisions to cause fundamental changes. In particular, then, this discussion is not concerned with legal definitions of "'discrimination'" as applied under the Act since discrimination has different meanings under different ratemaking models. Nor is it concerned with the importance of so-called "transportation characteristics" beyond their impact on costs of service, since transportation characteristics such as length of haul, loading weight, and gondola maintenance can all be reflected in railroad costs.

to prices and inversely proportional to elasticities of demand for the products being shipped. A corollary of this approach is that if two commodities are perfect substitutes (equal prices and price elasticities) then they should bear equal rates for the same shipment. The pure value-of-service approach is not concerned with the cost of service, except to ensure that all of a railroad's costs, including a reasonable return on investment are covered.

Under the equivalency variant of the value-of-service approach to ratemaking it is argued that, while virgin and secondary materials are not perfect substitutes on an equal weight basis, chemically equivalent batches of virgin raw materials and of secondary materials required to produce a unit of processed material output are substitutes and should bear the same rate for the same shipment. For example, production of 1 ton of raw steel requires just over 1 ton of ferrous scrap or a batch of iron ore, limestone, and coal weighing several tons. It is argued that the ton of scrap and the batch of raw materials compete and that under the value-of-service approach they should both bear the same aggregate freight rate. According to this argument, failure to achieve such equality of rates for equivalents is evidence of discrimination. On the other hand, if the fact that such competition is real cannot be established, then there would be no basis for a charge of discrimination.

DATA ON DISCRIMINATION

Cost-Based Rates.—Using the detailed cost and revenue evidence submitted by the railroads in Ex Parte 319, Moshman Associates developed data on comparisons of railroad revenues to variable costs and to fully allocated costs for the eight commodities of interest, as shown in table 16. (It should be noted that the Ex Parte 319 data have been criticized because they are not based on a statistical sample of all shipments.)

Table 16 shows that for all four pairs of scrap and virgin materials, the scrap material pays significantly higher revenues in comparison to both variable and fully allocated costs. Thus, for all four pairs, there is discrimination against secondary materials on these two bases.

The data in table 16 suggest that shippers of iron ore and pulpwood fail to pay the fully allocated costs of their shipment, and that pulpwood does not even fully cover the variable cost. Glass cullet, on the other hand, appears to contribute an inordinately high amount to costs of either type.

The apparent discrimination between the pairs of commodities could be removed by reducing the freight rates for the secondary materials or by increasing them for the corresponding primary ones. In either case, some target ratio, based, for example, on an average for all commodities, might provide a reasonable basis for adjustment.

Table 16.-National Average Railroad Costs and Revenues

	Variable cost ($/car)	Fully allocated cost ($/car	Revenue (S/car)	Ratio of revenue to: Variable cost	Ratio of revenue to: Fully allocated cost
Iron ore	242	354	329	1.36	.93
Ferrous scrap	294	346		1.71	1.46
Bauxite	645			1.47	1.07
Aluminum scrap. . .	4 4 3		811	1.83	1.50,
Glass sand.	361	489		1.55	1.14
Glass cullet.	621	816	1 , %	2.42	1.84
Pulpwood	241	307	218		.71
Paperwaste.	322	423	439	1 : :	1.04

SOURCE: Moshman Associates, Working Paper Two (5). Based on railroad submissions in Ex Parte 319.(23)

Value-of-Service-Basis. -Under the value-of-service approach to ratemaking, actual or estimated costs of service are of little concern; except insofar as total revenues must meet total costs. Using data from the 1974 One Percent Waybill sample of the ICC, and updating to 1975 by applying ex parte rate increases, Moshman Associates estimated the ratios of rail revenue to product value for each of the eight commodities, as shown in table 17.

On the basis of value-of-service rates, discrimination between noncompeting commodities is allowable and of little interest. Thus, no conclusions can be drawn about discrimination from the wide range of ratios of rail rates to product values among the four commodity pairs. However, the differences in ratios within pairs are significant.

Value-of-service rates allow higher valued, competing commodities to bear higher rates. Table 17 shows that this is the case for all four pairs of materials of interest. In each case the scrap material, which has a higher value per ton, also bears a higher freight rate. The value-of-service approach also allows for the competing product whose demand is more sensitive to price to bear a rate that is a lower fraction of product value. Since demand for scrap is less sensitive to its price than is demand for virgin materials, scrap might reasonably bear a rate that is an even higher fraction of price without being discriminatory. For the iron ore/ferrous scrap and glass sand/glass cullet pairs, the ratios of rail rates to product values are nearly the same for both virgin and scrap. This result suggests some discrimination against virgin materials for these pairs, assuming that they compete. Furthermore, a higher fractional freight rate for wastepaper would not appear to be discriminatory, per se. However, the respective ratios for pulpwood and wastepaper are 0.34 and 0.82, and this large difference suggests some degree of discrimination against wastepaper under the value-of-service approach.

The situation with bauxite and aluminum scrap illustrates the pitfalls of value-of-service ratemaking. If aluminum scrap were to bear a fractional rate per ton greater than that for bauxite, it would have to pay a minimum rate of 0.93 x ($322) or $300 per ton, (see table 17) an unreasonable amount compared with costs incurred by the railroads. Thus, while aluminum scrap bears an abnormally low fractional freight rate, suggesting discrimination against bauxite, it also bears the highest rate per ton of any commodity studied.

Equivalency Basis.—To test the arguments on discrimination under the value-of-service-for-equivalents approach, Moshman Associates first calculated typical amounts of various raw materials required to produce equivalent final products from either virgin or scrap inputs. They used a variety of data sources detailed in appendix B of their working paper.(5) The total raw materials costs, total transportation costs, and ratios of transportation costs to total costs were then calculated using freight rates from the 1974 Car-

Table 17.— Railroad Revenues and Product Values

Commodity	Average freight rate ($/ton)	Product value (FOB $/ton)	Ratio of average freight rate to product value
Iron ore	3.09	18.12	0.17
Ferrous scrap	8.65	55.39	0.16
Bauxite	10.20	11.01	0.93
Aluminum scrap	23.82	321.78	0.074
Glass sand	6.67	4.64	1.44
Glass cutlet	18.60	11.40	1.63
Pulpwood	3.59	10.56	0.34
Paperwaste	12.91	15.82	0.82

SOURCE Moshman Associates from one Percent Waybill sample from 1974 updated to 1975 (5) load Waybill sample updated to 1975 by application of ex parte increases. These results are shown in table 18. According to the chemical equivalency argument, substitutable batches of virgin and raw materials should bear the same total freight rates for the same shipment: if they do not, discrimination exists. Under this standard, data in table 18 show no discrimination against virgin steel (14.8 percent versus 13.5 percent of total costs attributed to transportation); substantial discrimination against virgin aluminum (34 percent versus 7.4 percent); and distinct discrimination against secondary glass (62 percent versus 44.8 percent) and secondary paper (44.9 percent versus 28.2 percent).

Summary of Evidence on Discrimination.—The determination of discrimination between virgin and secondary materials depends on both the particular material pair and, more importantly, the basis chosen for the definition of discrimination. The evidence from OTA'S study is summarized in table 19. (Data were not available for making a determination of discrimination on a marginal cost basis.)

The finding under the value-of-service approach for bauxite and aluminum scrap is questioned in table 19. Strict application of this approach shows gross discrimination against bauxite, but full correction of this situation would require unreasonably high rates for aluminum scrap.

Impact of Freight Rate Adjustments on Secondary Material Shipments by Rail

Using the analyses presented above, OTA has estimated changes in rail shipments of secondary materials that might occur if rates were adjusted to eliminate discrimination. In order to give the greatest advantage to secondary materials, rates for each of them are assumed to be reduced enough to eliminate the greatest level of discrimination against scrap found by any of the four methods. Then, changes in shipments are calculated using the elasticities of transport demand in table

Table 18.—Costs of Virgin and Secondary Raw Materials Required to Produce 1 Ton of Equivalent Output—1975 Dollars

Output product	Raw material input	Tons required to produce 1 ton of output	Cost to produce 1 ton of output: Total $	Transportation $	Transportation as 0/0 of total
Steel	Virgin	2.87	76.76	11.37	14.8
	Secondary	1.05	67.24	9.08	13.5
Secondary alumlnum	Virgin	7.57	209.53	71,17	34.0
	Secondary	1.09	376.70	25.96	7.4
Glass containers	Virgin	1.15	23.14	10.38	44.8
	Secondary	1,00	30.00	18.60	62.0
Paperboard	Virgin	3.47	53.04	14.97	28.2
	Secondary	1.12	32.18	14.46	44.9

SOURCE Moshman Associates (5)

Table 19.—Summary of Findings on Freight Rate Discrimination

Commodity pair	Basis for ratemaking: Variable cost	Fully allocated cost	Value of service	Equivalency
Iron ore/ferrous scrap	+	+	—	0
Bauxite/aluminum scrap. .	+	+	_(7)	–
Glass sand/cullet. .	+	+	—	+
Pulpwood/wastepaper	+	+	+	+

aDeffnltlons of discrimination are different for each ratemaking basis basis

Key. + discrimination against scrap
- discrimination against virgin
O no discrimination

SOURCE Off Ice of Technology Assessment

15 and the equation on page 57. The results are shown in table 20.

Table 20 shows that even though substantial rail rate reductions are justified under various ratemaking approaches, the resultant changes in scrap shipments are estimated to be quite low, except for glass. Furthermore, losses of railroad revenues from existing shipments would be large since rates would drop considerably but would not be made up by revenues from the increased traffic.

For example, a 36-percent decrease in rail rate for iron and steel scrap would increase rail shipments by an estimated 0.2 million to 1 million tons (about 0.5 to 2.9 percent), but would cause a reduction in rail revenues of $100 million to $110 million per year. This loss is equivalent to about $100 to $550 per ton of additional scrap moved, and is not economically justifiable from the railroad's perspective when iron and steel scrap is selling in the neighborhood of $50 to $100 per ton. On the other hand, the revenue loss for glass per incremental ton is comparable with the current price of recovered glass, although even in this case the railroads' loss of revenue on existing shipments is not made up by the gain in revenues from additional scrap shipments. However, regardless of its impacts on railroad revenues, discrimination among materials of the extent indicated by this anlysis should be eliminated.

The conclusion of this analysis is that substantial discrimination against secondary materials is found, if one adopts cost-based or equivalency-based railroad ratemaking. However, even using maximum estimates of discrimination as rationales for rate adjustment, an economic model projects increases in shipments in the short run of only a few percent for iron and steel, aluminum, and paper. Increases for glass might be as large as 15 to 25 percent. Railroad revenues would be substantially reduced by such actions. Smaller freight rate reductions would have less impact on railroad revenues, but would also stimulate smaller increases in scrap shipments. In addition, only a fraction of the increased shipments under rate reductions might originate as resources recovered from MSW. No estimates have been made of the possible long-run effects of freight rate adjustment on recycling. As new manufacturing facilities are built in the future, lower freight rates for secondary materials could provide an inducement to increase the amounts of recovered materials used.

Table 20.—Estimated Impact of Freight Rate Adjustments on Secondary Material Shipments and Railroad Revenues

	Material			
	Iron and steel	Aluminum	Glass	PaDer
Percent reduction of freight rate required to eliminate discrimination	36	29	50	52
Indicator of maximum discrimination	fully allocated cost	fully allocated cost	equivalency	equivalency
Estimated percent change in shipments	0.5 to 2.9	0.06	15 to 25	3.6
1974 rail shipments of scrap" (million tons)	36	0.46	0.28	5.2
Estimated increase in 1974 shipments (thousand tons)	200 to 1.000	0.3	45 to 67	190
Estimated loss in 1974 railroad revenues (million $)	100 to 110	3.2	1.4 to 1.8	32
Revenue loss per extra ton shipped ($/ton)	100 to 550	11.000	20 to 40	170

a Moshman Associates (5)

SOURCE Office of Technology Assessment

Findings on the Marketability of Recovered Resources

Substantial amounts of various materials and energy types can be recovered from MSW today using either centralized separation and recovery or separate collection. The quantities of potentially recoverable resources in MSW are expected to grow in the future as the total use of materials grows.

Productive uses can be made of recovered iron and steel, aluminum, paper, glass, and energy using existing technologies and in existing facilities. However, the prices users are willing to pay and the product quality they demand could be barriers to the profitable sale of large amounts of recovered resources if resource recovery were widely adopted. Potential markets exceed any anticipated level of recovery today and through 1995 for iron and steel, aluminum, and paper. Glass markets are developing rapidly as the economic, environmental, and energy advantages of container production from waste glass become apparent. Energy markets far exceed the potential level of recovery from MSW nationwide. Certain forms of energy, however, including RDF, steam, and low-Btu gas, must be produced near potential users if transportation costs are to remain acceptable.

Established markets for secondary iron and steel, aluminum, and paper exhibit wide variations over time in both prices and quantities traded. However, prices for postconsumer aluminum from separate collection programs have been more stable because primary aluminum companies have been offering stable prices to recyclers, Newsprint recycling mills have begun to stabilize markets for waste newspapers in some areas. Current trade in waste glass is small but growing rapidly, with relatively stable prices, A brief analysis of a Federal stockpile for recovered resources suggests that this would be unnecessary, ineffective, or overly expensive for stabilizing markets for materials recovered from MSW.

At any forseeable level of recovery, iron and steel from MSW would be un]kely to disrupt existing secondary markets for this commodity. High levels of additional aluminum and paper recovery would add substantially to the current trade. Glass recovery essentially represents creation of an entirely new market rather than disruption of an existing one. In view of the current energy situation and the relatively small amounts recoverable from MSW, energy from waste represents no threat to established energy markets.

Federal procurement policy can strengthen markets for recovered materials by emphasizing their use and by eliminating arbitrary barriers to them. Existing General Services Administration regulations under RCRA, if followed, represent a substantial move in this direction.

Federal R&D support on uses of recovered resources, as opposed to their production, is limited, even though such research might find new uses and improve old ones and is easily justifiable on economic grounds. Under RCRA only the Department of Commerce has authority in this area, and that authority has not been funded. The Bureau of Mines has done limited work in this area under its basic authority. Additional Federal support for R&D on uses of recovered resources appears to be desirable,

Specifications for the quality of recovered resources are necessary largely to facilitate trade, rather than for consumer protection purposes, since few recovered resources reach consumers without further industrial processing. (Important exceptions are flammability standards for cellulosic insulation, recently established on an emergency basis by act of Congress, and health and safety standards for reusable beverage containers.) Existing specifications based on the origin of secondary materials, promulgated by the secondary materials industries, appear to be adequate to support trade in separately collected iron and steel, aluminum, and paper, but not for trade in materials and energy from centralized resource recovery plants. Composition specifications for the latter kinds of products are currently in the final stages of development by a committee of the American Society for Testing and Materials. Separately collected glass is currently traded under quality/price negotiations for each shipment. In view of the current state of voluntary standards activity, there seems to be no need for Government action beyond that authorized under RCRA.

Freight rates for transportation of recovered materials and certain forms of recovered energy to markets can seriously impair the economics of resource recovery. For shipments by rail in the 200- to 400-mile range, railroad freight rates can range as high as 25 to 80 percent of the gross income from the sale of waste iron and steel, paper, glass, and RDF. Even a 50-percent reduction of freight rates for these resources, for example, would still leave freight charges a substantial cost factor.

Demand for railroad freight services is not very sensitive in the short run to rates for secondary iron and steel, aluminum, and paper, but is more sensitive for glass. For the insensitive materials, large freight rate changes would have little effect on shipments.

Whether existing railroad freight rates discriminate against secondary materials was examined in the frameworks of several theoretical models of ratemaking. Such discrimination is substantial for iron and steel, aluminum, paper, and glass under cost-based rates (both variable and fully allocated costs], and for paper and glass under the chemical equivalency approach to value-of-service rates. Such discrimination was not found under the value-of-service approach to rates. Clearly, then, part of the long-standing controversy over discrimination against secondary materials arises from different assumptions about how rates ought to be set.

Assuming that freight rates were adjusted downward for secondary materials (iron and steel, aluminum, glass, and paper) to eliminate the greatest level of discrimination indicated by any of the models examined (reductions on the order of 30 to 50 percent), increases in shipments by rail are estimated to be on the order of a few percent or less for waste iron and steel, aluminum and paper. Glass shipment might increase by as much as 15 to 25 percent. Correspondingly, railroad revenues in each case would decline substantially since revenue losses from existing traffic would not be offset sufficiently by traffic growth. Somewhat larger increases in shipments might occur in the long run.

Regardless of the small increases in shipments and the large decreases in railroad revenues, however, under cost-based rates these secondary materials are treated unfairly by existing freight rates. Both equity and efficiency argue for their adjustment. Railroad revenues, if inadequate. can be adjusted by general rate increases.

References

1 Resource Technology Corporation, "Market Prognosis: Recyclable Goods Available From Municipal Solid Waste.'" in Working Papers on Materials and Energy From Municipal Waste, Congress of the United States, Office of Technology Assessment, OTA-M-69, July 1978.
2. Black and Veatch, and Franklin Associates, Lt"d., Detailed Technical and Economic Analyses of Selected Resource Recovery systems, report for the Mid America Regional Council, Kansas City, Mo. (1978).
3. American Metal Market, Metal Statistics 1977; Fairchild Publications, New York: 1977.
4. U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Indexes.
5. Moshman Associates, Inc., "Effect of Freight Rates on the Movement and Sale of Selected Recyclable Commodities, " in Working Papers on Materials and Energy From Municipal Waste, Congress of the United States, office of Technology Assessment, OTA-M-69, July 1978.
6. Alter, Harvey, "Development of Specifi-Cations for Recycled Products, Conservation and Recycling, 2 (1979).
7. Paper Stock Institute of America, National Association of Recycling Industries, Paper Stock Standards and Practices, Circular PS-77, Jan. 1, 1977.
8. National Association of Recycling Industries. Standard Classifications for Nonferrous Scrap Metals, Circular NF-77, May 1, 1977.
9. Institute of Scrap Iron and Steel, Specifications ,for Iron and Steel Scrap, 1975.
10. Glass Packaging Institute, Washington, D. C., telephone conversation, Mar. 26, 1979.
11. Duckett, Joseph, National Center for Resource Recovery, telephone conversation, Mar. 26, 1979.
12. Kramer, Larry. "Bottle Maker Cuts Costs, Pollution with Old Glass, " Washington post. July 2, 1978.
13. Howard. Stephen E., "Status of Glass Recovery and Marketing Through Source Separation in the Northeast Corridor, " unpublished report, U.S. Environmental Protection Agency, July 26, 1978.
14. Solid Waste Report, Mar. 12, 1979, p. 47.
15. Davis, Robert, Garden State Paper Company, telephone conversation, Mar. 30. 1979.
16. U.S. Department of Commerce, Bureau of the Census, Current Industrial Report: Pulp Paper and Board Summary, Series M26A 1969-1976.
17. U.S. Department of the Interior, Bureau of Mines, (Commodity Data Summaries 1977.
18. U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, Resource Recovery and Waste Reduction. Fourth Report to Congress, EPA Publication SW-600, (Washington, D. C.: U.S. Government Printing office, 1977), pp. 17-18.
19. Kovacs, William L., and John F. Klucsik, "The New Federal Role in Solid Waste Management: The Resource Conservation and Recovery Act of 1976,'" Columbia Journal of Environmental Law, 3:2, 205-261 (1977).
20. Office of Technology Assessment, An Assessment of Alternative Economic Stockpiling? policies, 1976,
21. Moshman Associates, op. cit., p. 272.
22. Anderson, Robert C., and Richard D. Spiegelman, Impact of the Federal Tax Code on Resource Recovery, prepared for the U.S. Environmental Protection Agency. EPA Report 600 5-76-009, December 1976,
23, Interstate Commerce Commission, Ex Parte No. 319.
24. Page, R. Talbot, Conservation and Economic Efficiency: An Approach to Materials Policy; published for Resources for the Future by the Johns Hopkins University Press, Baltimore, 1977.
25, Friedlaender, Ann F., The Dilemma of Freight Transport Regulation, the Brook-

ings Institution, Washington, D. C., 1969.

26. Fair, Marvin L., and Ernest W. Williams, Jr., Economics of Transportation and Logistics, Business Publications, Inc., Dallas, Tex., 1975.

27, Friedlaender, op. cit., pp. 132-135.

Chapter 4

Source Separation for Materials and Energy Recovery

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Tables

Source Separation for Materials and Energy Recovery

Introduction

Definitions and Issues Addressed

Source separation* is "the setting aside of recyclable materials at their point of generation (e.g., the home, or places of business) by the generator. Once recyclable materials are separated, they may be transported to a secondary materials dealer or manufacturer by the generator, municipal collection crews, private haulers, or community organizations.'"(l) Some familiar approaches to source separation are curbside collection of newspapers, cans, and glass; commercial recycling of waste office paper, corrugated cardboard, and computer cards; and communit y dropoff centers,

By comparison with mechanical separation of collected mixed wastes in centralized resource recovery plants, source separation is labor intensive, produces relatively uncontaminated materials for recycling from a portion of the waste stream, and requires greater cooperation by waste generators. Centralized resource recovery, on the other hand, is capital intensive, and can accept most kinds of collected waste thus reducing the need for cooperation. Because source separation can put a greater burden on collection, the most costly part of municipal solid waste (MSW) management, successful source separation programs require considerable attention to design and implementation strategies.**

*'*Source separation" is a misnomer, Rather than separation, householders and other generators of waste simply avoid mixing waste prior to collection.

**Design and implementation strategies for centralized resource recovery plants, are discussed in detail in chapters 6, 7, and 8.

Four principal questions are addressed in this chapter:

- Is source separation an economically and technically feasible approach to resource recovery, and what are its potentials for materials recovery and energy savings?
- What issues and problems arise in connection with source separation?
- How does source separation interact with other approaches to resource recovery, recycling, and reuse?
- What Federal policy options are available or necessary to facilitate, stimulate, or regulate source separation?

Advantages, Disadvantages, and Impediments to Source Separation

The advantages and benefits of the source separation approach to recovery and recycling of materials are that it:

- produces high-quality waste products*** that can bring a premium price if markets are available and if recovered products meet market specifications;
- is the only method currently available for the recovery from MSW of recyclable newspaper, office paper, corrugated cardboard, color-sorted glass, plastics, and rubber;
- conserves energy by recovering materials whose production from virgin sources is energy intensive;
- requires very little capital investment as compared with centralized resource recovery;

***Curbside collected materials may need to be upgraded to meet market specifications.

- can be implemented with little delay in comparison with centralized resource recovery facilities; and
- may be the only way a small or remote community could recycle materials if the population is too small to support a centralized resource recovery plant.

Some local independent trash haulers, scrap dealers, and scavengers might find source separation more attractive than centralized resource recovery because it protects the part of their income derived from sales of high-grade waste materials.

The possible indirect advantages of source separation include:

- Decrease air and water pollution from landfill activity.
- Net savings from avoiding negative impacts on the environment, on worker health, on energy, and on resources from the production of virgin materials.
- Improved balance of trade from substituting recycled for imported virgin materials.
- Communities with source separation programs are seen to be forward-looking,
- Benefits from a sense of personal involvement in conservation activities.

Some of these benefits such as the reduced use of virgin materials and of landfill space are also true for centralized resource recovery.

The disadvantages of source separation are:

- Only a portion of the waste generated can be recovered.
- It leaves a mixed waste residue that has a somewhat lower fuel content than unseparated mixed waste.
- It strongly depends on individual participation and cooperation.
- It requires modification of the costly collection equipment used by both municipal and private haulers.

The chief impediments to implementing source separation are:

- Uncertainty about cooperation in the short- and long-term by householders, businesses, and others who generate waste.
- The uncertainty of markets for recovered materials along with the reluctance of consumers of recycled goods to sign long-term purchase contracts (in view of uncertain community participation and the problems associated with recycled materials meeting market specifications).
- The costs of transporting recovered materials from remote communities to the fabricating plants of potential purchasers.
- Inadequate attention by the Federal Government to the innovative design of programs, incentives, and contaminant control research so that source separated materials can meet market specifications.
- The belief that low-income and urban householders will not cooperate with source separation programs.

The rest of this chapter examines these advantages, disadvantages, and impediments to source separation and discusses possible policies for dealing with them.

The Technical and Revenue Potentials of Source Separation

Five kinds of programs for source separating materials are: (i) separate curbside collection of materials from residences—newspapers only or multimaterials (paper, cans, glass); (ii) multimaterial recovery in community recycling/reclamation centers; (iii) industry sponsored recycling programs; (iv) office paper recovery programs; and (v) commercial and industrial source separation activities. These types of programs make possible the recovery from the waste stream of such materials as: newspapers, books and magazines, corrugated paper, office paper, glass containers and other glass, steel containers, aluminum containers, and yard waste. The following sections examine source separation's potential for recovering materials, saving energy, and earning revenue.

Materials Recovery

The potential of source separation to achieve its main goals of reducing the flow of solid waste to disposal and of conserving natural resources has been estimated by OTA. This estimate only attempts to convey the sense of what might be accomplished. It does not purport to forecast the actual future levels of source separation activities.

Table 21 shows the amounts of major source separable materials in MSW along with estimates of the amounts recoverable at each of two national average levels of participation. * These estimates suggest that at 50-percent participation as much as 37.4 million tons, or 27 percent by weight, of the gross discards of MSW might be recovered. According to estimates by the Environmental Protection Agency (EPA), only 6.3 million tons of MSW were actually recycled in 1975.

The potential of source separation may be underestimated in table 21 because products such as plastics, paper packaging, and other paperboard might be added to the list. In addition, wastes such as miscellaneous glass, noncontainer iron and steel, and aluminum foil could be recovered with the basic components. It should be noted, however, that the most successful source separation programs recover only 2 or 3 categories of materials at a time from the waste stream. A total of 26,1 million tons of yard wastes have been included in table 21. Much of this waste (leaves, grass clippings, garden waste, etc.) can be separately recovered for conversion to compost and mulch, providing both a soil conditioner and a partial substitute for chemical fertilizer. At even 25-percent participation in the separate collection of yard waste, the MSW total could be reduced by 6,5 million tons (about 5 percent).

From the estimates for recoverable materials in table 21 it can be seen that while source separation can substantially reduce a community's total wastes, more than half will still have to be disposed of by other methods. Thus, source separation can only serve as part of of a community's waste management program,

Energy Savings

In order to produce basic materials (from virgin or secondary materials) energy is needed to process and transport fuels, to mine and process raw materials, to operate waste collection and separation plants, to heat and light operating facilities, etc. Recovering materials for recycling by means of source separation can save energy. The energy saved would come from the difference between the energy needed to produce a given amount (e.g., 1 ton) of a basic raw material (e. g., steel) from virgin raw materials and the energy needed to produce an equal quantity of the same basic material from recycled raw materials. Estimates of the potential savings in million 13tu per ton of recovered materials are summarized in column 2 of table 22. From the data, it can be seen that a large amount of energy is saved in recycling aluminum, somewhat less with steel and paper, and considerably less with glass. Table 22 also shows the energy that could be saved per ton of waste generated for both 25- and 50-percent participation in source separation programs. Energy savings compared with landfilling range from 0.7 million to 1.4 million Btu per ton of generated waste. (The interaction of centralized resource recovery and source separation is discussed later in

*Participation is used here to mean the fraction of each waste component that is recovered. Thus, 25-percent participation would occur if one-fourth of the population recovered all of the recoverable components of its waste or if half of the population recovered half of the recoverable components of their waste on the average. Since the major recoverable components make up 55 percent of total waste (see table 21), 25-percent participation in a comprehensive program would result in recovery of one-fourth of this 55 percent, or about 14 percent of total waste. Likewise, 50-percent participation would recover about 28 percent of total waste.

Table 21.-Major Source-Separable Components of MSW, 1975

Material	Amount in MSWa		Amount recoverable by source separation (million tons)		Recycling experience in 1975 (All methods)a	
	Percent	Million tons	25% participation	50% participation	Million tons	'%recycled
Newspaper	$.5	8.9	2.2	4.5		20
Books and magazines....,	2.3	3.1	0.78		6	8
Corrugated paper	9.2	12.5	3.1 ,	:::		22
Office paper . . . ., . .					::;	13
Glass containers	;::	1:::	;::	H		
Steel containers	4.0		1.4	2.8	::;	:
Aluminum containers. . . .	0.4		0.14	0.27	0.08	15
Yard waste		26.0	6.5	13.0		
Total major source-separable materials	55.1%	74.2	18.5	37.4	6.3[d]	

source; Table 4 .Latest year for which data are available.
Includes all aluminum cans and aluminum parts of bimetallicp cans
An unknown amount of yard waste is collectedseparatly and used as compost or mulch
an additional 1.7 million tons of other materials from MSW wererecycled in 1975
NOTE: These estimates assume no action to institute product disposal charges, madatory cotainer deposits, or centralized resource recovery plants.

this chapter.) For the entire Nation these savings are equivalent to 0.1 to 0.2 Quad* annually or to 0.14 to 0.28 percent of the Nation's energy use.

Revenue Potential of Source Separation Programs

The chief direct economic benefits of source separation programs are the proceeds from selling the recovered materials and the credits for avoiding part of the cost of disposal by landfill or other means. In this analysis, disposal credits are assumed to be proportional to the weight of waste removed; that is, average landfill costs are used in their estimation.

The potential gross revenues from source separation programs can be estimated by multiplying the estimates of recoverable quantities of materials in table 21 by estimates of scrap prices. Table 23, which summarizes such revenue estimates for 25- and 5C)-percent program participation, shows that these are highly dependent both on realizable scrap prices and on participation. It further shows that no single waste component produces a large share of the total revenues, although various paper types together account for well over half of them. Depending on local landfill costs, credits for avoided disposal costs can be significant.

*One Quad equals 10^{15} Btu = 1.055 EJ.

A complete economic analysis of source separation must take into consideration all of the following factors: the direct costs of promotion and collection and the direct benefits of revenues from recovered materials and avoided disposal fees; also the indirect costs of consumer inconvenience and the indirect benefits of energy and materials savings and environmental protection. The economic implications of the interactions among source separation, centralized resource recovery, and beverage container deposit legislation must also be considered. No direct cost data are available for constructing a cost table analogous to table 23. Cost data for specific recovery programs are discussed in subsequent sections of this chapter.

Status of Source Separation programs in the United States

Source Separation Methods and Approaches

Source separation programs vary depending on the sponsorship, the types of materials collected, the frequency of collection, and whether materials are collected at curb-

Table 22.—Estimated Potentiai Energy savings From Source Separation Programs

Material	Potential energy savingsa (million Btu/ton)	Potential energy savings per ton of MSW generated (million Btu/ton) 25% participation	50% participation
Newspaper	5.2	0.08	0.17
Books and magazines	5.2	0.08	0.17
Corrugated paper..	5.2	0.08	0.17
Office paper	5.2	0.08	0.17
Glass containersfJ	1.2	0.03	0.06
Steel containers.	7.8	0.08	0.16
Aluminum containers	259.4	0.26	0.52
Yard waste	0[c]	Oc	w
Total energy savings. . . .		0.69	1.42

OTA estimates based on data in reference(2),(3), and(4).

In this report recovery of yard waste in source separation programs Is assumed to produce only landfill Credits and neither energy savings norr net revenues. This choice is made becauae yard waste is quite varied seasonally and geographically and because experts disagree widely about the viability of yard waste utilization or sale. The effects of this choice are to underestimate by a small amount the economic and energy potentials of source separation.

side or delivered to a recycling center. Five methods of source separation are discussed below: (i) curbside separate collection programs; (ii) multimaterial recovery in community recycling/reclamation centers; (iii) industry sponsored recycling programs; (iv) office paper recovery; and (v) commercial and industrial methods of source separation.

Curbside Separate Collection Programs

STATUS

In curbside separate collection programs* recyclable materials are conveniently collected at curbside, rather than having to be transported by householders, businesses, or other generators of waste to a recycling center. Such programs fall into two categories, those that collect only one recyclable material, in most cases some form of wastepaper; and those that collect two or more. In a recent survey, EPA estimated that as of May 1978, there were 218 curbside separate collection programs in the United States. (See table 24.) Of the programs surveyed,** 99 percent collected some form of paper (76 percent collected newspaper and 23 percent collected mixed wastepaper), glass was collected by 16 percent, and metal by 14 percent. Collection was the responsibility of municipalities in 57 percent of the programs and of private collection firms and community organizations in 29 and 12 percent of the programs, respectively.(5)

In most communities, collection programs divided household waste into two, three, or four segments. Division into two segments separates newspapers from the remaining waste. (Some cities collect a mixed flat paper segment instead of newspapers alone.) Division into three segments separates cans and bottles as well as newspaper from the remaining waste; and into four segments separates newspapers, clear glass and cans, and green and brown glass and cans from the remaining waste.

The factors a community must weigh in deciding the number of segments to collect include: anticipated participation, the comparative cost of centralized separation, the

*This section discusses only curbside collection programs sponsored by municipalities or private collectors on a regular basis, There is a significant amount of activity, primarily for newspaper, in occasional curbside collection by voluntary organizations and in house-to-house collection by private entrepreneurs. No statistics are available on the extent of this activity, although total newspaper collection statistics suggest it is large.

A*AS of September 1977, the EPA had identified ZOS separate collection programs, Only 177 of these contained enough information to be included in the sample. Since this date, the EPA has located an additional 13 programs. These were not included in the survey,

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Table 23- Estimated Potential Gross Revenues From **Servirce Separtation Programs**

Material	Potential Unit revemie ($/ton)	Potential revenue per ton of MSW generated ($) 25% participation	50% participation
Newspaper	20-45	0.3390.73	0.88-1.48
Booksand magazines		0.0%0.12	0.08-0.23
Corrugated paper	I L ?	0.35=1.04	0.702.07
Office paper.	75-120	0.71 -1.14	1.43-2.28
Glass containers	20-30	0.48-0.89	0.92=1.38
Steel containers. . . . •.	20-40	0.200.40	0.404.80
Aluminum containers.		0.30	0.80
Yard waste			
Total revenues		2.384.42	4.77-8.82
Credits for disposal avoidance.	2-10	0.28-1.38	0.55-2.76
Grand total revenues and credits		2.88-5.80	5.32-11.58

Revenues must be reduced to account for freight.

OTA esto,ates based on various industry sources. Ranges indicate

j~;c"% -w of y~w- }n Hw ~ ~n ~wrama is aaaumed to produoa only landfill oredlts and n@thW energy savings nor net revenues. This choke is made because Yard waste is quite varied seasonal ly and geographically and because experts disagree widely about the viability of yard waste utilization or sale. The effects of this choice are to under. estimate by • small mount the economic and energy potentials of source separation.

Table 24.—Separate Collection Programs (May 1978)

Federal regions of the United States	Numbers of programs
Rqionl•...•' . . . . . . •.,..	48
R e g i o n | |	74
Region IIIf, ' » « •	12
Region V.	;
-~.**** *J•*•• °*	4
Re@%t-w...• • ... . ..* ..	$
Raf#qnv&. . * * „ .. ?-„ $.	
@3@@n#f* ..-* . ...* .' *	2
Region X	9
Total.	fh "'

SOURCE: Based on David M. Cohen, *Separate Collection Programs: A National Survey*, U.S. EPA, 1978, appendix B.

value of the materials, and the product demand. Tradeoffs are involved in the decision. On the one hand, as the number of segments to be separated is increased there is a drop-, off in participation and an increase in the complexity and thus cost of the equipment. On the other hand, however, the cost of subsequent processing is reduced and the quality and value of the products improve.

PARTICIPATION

Communities need to be sensitive to tradeoffs between material quality specifications on the one hand and household convenience and participation on the other. For example, programs that require the removal of labels and metal rings from glass containers, or residual organic matter from all containers may seriously deter cooperation. Reduced participation is traded against the fact that contaminated materials bring lower prices.

Some communities have designed special containers for newspaper disposal that are distributed to each household. Such containers reduce the time needed by each household, protect the papers in case of rain, and help remind each household of the separate collection program's objectives. Some programs, which separate waste into three or four segments, use a trash receptacle with several compartments. One such container was developed by a recycler in New Hampshire and marketed briefly by Sears, Roebuck & Company.

Various approaches have been suggested for increasing the participation in separate collection programs. One is to provide color-coded plastic bags for different waste segments, Another is to charge lower fees for collection of separated wastes, This latter approach was tested in an experimental l-year study by the Seattle Recycling Project under a grant from the Washington State Department of Ecology. In one of the project's test groups a monetary rebate was offered which was approximately equal to the estimated reduction in collection and disposal costs from separated wastes. One of the study's conclusions indicated that while the monetary incentive was most effective with respect to voluntary participation at the project's inception, it did not have a continuing effect through the entire test period.(6)

To stimulate participation, communities have also tried a variety of advertising and public awareness campaigns, Typical methods include development of a recycling program logotype to help citizens identify with the program, placing information in newspapers and community newsletters, utilizing neighborhood organizations to distribute program information, buying time on radio and television to announce the start of programs or changes in the pickup schedule, posters featuring program information, community calendars containing pickup schedules, and/or a letter to each household from the mayor or leading city official endorsing the source separation program. Leadership by elected officials is important, and personal contact by community volunteers can help explain programs and encourage participation,(7)

Another method for increasing public participation in separate collection programs is to pass ordinances that require participation and levy fines for noncompliance. EPA's national survey of separate collection programs found that 24 percent of the programs surveyed had ordinances mandating that residents separate recyclable materials from mixed refuse. It was found that with residents of similar socioeconomic characteristics, and using the same collection frequency and publicity campaigns, the likelihood of participation is greater in mandatory programs, At the same time, however, most communities indicated that separate collection ordinances are not strictly enforced owing to the difficult y of apprehending violators.

Scavengers— unauthorized persons who pick up recyclable material before the municipal or private collector arrives—also create problems for many separate collection programs, Their impact is the greatest when scrap material prices are high. Some communities have enacted antiscavenging ordinances, These usually state that it is unlawful for any unauthorized person or firm to collect the separated material or materials. Fines for noncompliance range between $25 and $250. Such ordinances need not necessarily prevent service, charitable, or religious organizations from collecting such items as newspapers in volunteer drives.

A number of communities have passed ordinances requiring that all collected MSW be delivered to a specified location as a means of assuring a steady flow of waste to a centralized resource recovery facility, This has been done, not to protect public health, but to guarantee the economic viability of centralized resource recovery plants in the face of competition from separate collection programs or lower cost landfill. According to the information presented above, it appears that such ordinances are unnecessary if adequate attention is paid in advance to the complementary roles of various disposal options. Furthermore, such requirements may act as a barrier to adoption of economically preferred recovery and disposal methods, (See chapter 8 for a discussion of current legal challenges to such ordinances.)

INCONVENIENCE AND ASPECTS OF HOUSEHOLDER COST

To participate in sepa'rate collection programs, residents must devote time, equipment, and storage space, whose costs are largely unknown and controversial. One problem is to differentiate clearly between the costs of handling mixed waste and separated waste. Another is to put a value on both the time and the residential space required for waste segregation, since it is difficult to determine the value of alternative uses of such time and space.

Under an EPA grant, the League of Women Voters of Newton, Mass., kept a record of the time required to separate recycled materials, above the time normally required to dispose of waste. They found that it took an average of 15 minutes per week per family (range 1 to 20 minutes).(7) It has been argued, however, that the time spent in waste separation should be given a positive value since it may be associated with good feelings about contributing to conservation of resources, or it may be done by children and have some educational value. There is no agreement on the analysis or interpretation of these costs.

The inconvenience of storing recyclable materials depends on the frequency of collection. A biweekly collection program would create a smaller storage problem than one that collected on a monthly basis. EPA's survey of separate collection programs indicates that approximately 70 percent of the 177 programs surveyed collected recyclable at least twice a month, with the majority of programs collecting once a week.(8)

The value per square foot of the additional residential storage space that might be needed for the wastebaskets to be used for separate collection programs has been raised as a potential cost. For example, if separate collection of recyclable requires two extra containers that each occupy one square foot, the cost of extra waste container space for a family of four who pay $400 per month for a dwelling space of 1,200 square feet ($4 per square foot per year), would be $3.13 per ton of generated waste. (It should be noted that it would take this family approximately one-half year to generate a ton of waste.) It can be argued, however, that this cost is not real because there is a question about whether such wastebaskets would actually require additional residential space.

The cost of extra containers for separate collection programs can also be estimated. Two extra permanent containers might cost $4 each and last for 3 years. For a family of four, this would be equivalent to $1.04 per ton of generated waste. Separate collection programs might also require additional consumer expenditures for plastic trash bags, depending on the design of the system and the frequency of collection.

According to these estimates, the total additional consumer costs would be approximately $4 per ton. But the out-of-pocket costs would be much less, perhaps as little as $1.00 per ton for extra containers.

SEPARATE COLLECTION OF ONE RECYCLABLE AT CURBSIDE

The majority of separate collection programs in the United States collect just one recyclable material. EPA's data from its national survey on separate collection programs indicate that approximately 99 percent of the 177 programs surveyed collected some type of wastepaper.(9) Twenty-three percent of the programs surveyed collected some form of mixed wastepaper. Of the 133 programs that collected newspapers, 110 collected no other recyclable but newspapers. In addition, 32 of the 41 programs that collected mixed wastepaper collected only this one recyclable component. Apparently, a large number of communities only recycle newspapers because wastepaper markets are more readily available than markets for other recyclable, and because newspapers constitute a large and easily separable part of the waste stream. By removing them the lifetime of a community's landfill is increased. It should be noted that EPA's survey indicated that only three of the programs surveyed collected just glass or metals.

Various methods are used by municipalities and private haulers when collecting one material separately. These include using: separate trucks, racks attached to packer trucks, and trailers attached to the rear of a refuse collection vehicle.

The majority of programs (72 percent) use separate trucks, usually on a different day than the one for regular waste collection. This method has the advantage of low startup costs. Some of its disadvantages are: (a) recyclable must be collected on a separate day from regular waste collection—perhaps confusing residents about the waste collection schedule: (b) high operating costs—the revenue obtained from the collected recyclable material must offset the costs of collecting it: (c) trucks can be used for the collection of only one material at a time unless they are modified for the purpose: and the material must be unloaded by hand if noncompacting trucks are used.

A second method, referred to as the piggyback system, is used by 22 percent of the programs. One recyclable—usually newspaper—is collected in a rack attached to a packer truck. Startup costs for racks range from $80 to $250,(11) and operating costs are lower than for other collection methods.

A third method, used by 5 percent of the separate collection programs, is the use of trailers that have sufficient storage space (4 to 6 cubic yards) and can be unloaded mechanically, which are attached to the rear of a refuse collection vehicle. This method also permits the recyclable and the mixed refuse to be collected at the same time. Its operating costs are relatively low, but startup costs tend to be quite high, ranging from $3,000 to $3,500 for each trailer. There may also be a problem with maneuverability.

Madison, Wis,, has been recycling newspaper since 1968 when it initiated a pilot separate collection program involving half the city, The rest of the city joined the program in 1gi'o. At the start, the city made separate collection trips for newspapers. But collection costs were too high, so the piggyback method was adopted. Even though Madison does not mandate separation, in 1977 about 13 percent of the population participated. In that year 1,365 tons of newspaper were collected for which the gross revenues were $43,982. The cost of collecting the newspaper was $4.36 per ton, and the "profit" from its sale was $27.86 per ton.(12)

MULTIMATERIAL PROGRAMS

In May **1978,** about 40 multimaterial programs collected two or more recyclable materials at curbside. (The programs are listed in table 25.)(10) These included some combination of newspapers, magazines, corrugated paper, glass, and aluminum and steel cans. The majority of the multimaterial collection programs are located in the northeastern and western sections of the United States because of both the unusually high landfill costs ancl the availability of markets for the recovered materials in these regions.

Most of the programs that collect both color-mixed glass and cans handle either a stream combining the mixed glass and the cans or a stream of the mixed glass and a stream of the ferrous and nonferrous cans. Programs that collect both color-separated glass and cans collect at least two streams of glass; one clear and the other colored (amber and green). Both glass streams are usually mixed with cans. A third stream consisting only of cans may also be handled. Most multimaterial curbside programs use compartmentalized trucks, others use trailers attached to the rear of a refuse collection vehicle. An advantage of using compartmentalized trucks is that their operating cost is relatively low because recyclable materials are collected at the same time as mixed refuse. A disadvantage is that the startup cost is relatively high. In 1976, a compartmentalized truck cost approximately $20,000.

Two of the best known of the 40 multimaterial curbside collection programs are those in Somerville and Marblehead, Mass. In 1976, these communities were assisted by EPA grants to recover glass, cans, and paper from households. Marblehead is a relatively affluent suburban community that has been involved with recycling activities for some time. Somerville is a less affluent, densely populated urban community with no previous recycling experience. Marblehead passed an

Table 25.—Waste Components Recovered in Multimaterial Curbside Separate Collection Programs

Program	Waste component collected: Newspaper	Paper	Magazines	Glass	Clear glass	Colored glass	Corrugated paper	Cans	Aluminum cans	Metals	Other materials
Abington, Pa.	X				X						
Andover, Mass.		X			X			X			
Arcata, Calif.				X			X			X	
Atlanta, Ind.	X		X	X				X			
Bedford, Mass.	X			X				X			
Boulder, Colo.	X			X					X		X
Bound Brook, N.J.	X			X				X			
Bowie, Md.					X						
Brooklyn Center, Minn.	X							X			X
Clifton Heights, Pa.		X		X							
Davis, Calif.	X			X				X			
Downey, Calif.	X			X				X			
Durham-Middlefield, Conn.	X			X							
East Lyme, Conn.	X		X	X				X			
El Cerrito, Calif.	X		X	X			X	X			
Fresno, Calif.	X			X				X			
Greenbelt, Md.	X								X		
Hamilton, Mass.	X			X				X			
Hartford, Conn.	X									X	
Ithaca, N.Y.				X					X	X	
Livermore, Calif.				X			X			X	
Mankato, Minn.	X							X			
Marblehead, Mass.	X			X				X			
Modesto, Calif.	X			X				X			X
New Hartford, Conn.		X		X				X			
Newington, Conn.	X				X						
Newton, Mass.	X			X				X			
Omak, Wash.	X			X				X			
Rockville, Md.	X									X	
Rutherford, N.J.	X				X						
San Anselmo, Calif.	X						X		X	X	
San Luis Obispo, Calif.	X			X				X			
Somerville, Mass.	X			X				X			
Summit, N.J.		X		X							
Topsfield, Mass.	X			X			X	X			
Wabash, Ind.	X			X				X			
Waltham, Mass.	X			X			X	X			
Waterbury, Conn.				X				X			
West Orange, N.J.	X			X							
Winchester, Conn.		X		X				X			

SOURCE: Based on David M. Cohen, *Separate Collection Programs: A National Survey*, U.S. EPA, 198, appendix C.

ordinance requiring source separation of recyclable, while Somerville's program was voluntary. A full-scale public education program was undertaken in both areas. Both communities obtained contracts for sale of the materials through competitive bidding.

In the first 9 months of operation, Marblehead recovered 23 to 33 percent of its residential waste each month, while Somerville recovered 7 to 9 percent.(12) In 1977, recovery rates for the residential waste stream averaged 25 percent in Marblehead and 5 percent in Somerville. These results imply participation rates considerably greater than these fractions, since only portions of the waste streams were to be recovered. Overall costs for solid waste management were reduced in Marblehead as a result of the separate collection program. Before the program was initiated Marblehead used four vehicles to collect waste twice per week. A contractor's report prepared for EPA found that because of the reduction in the amount of waste to be collected as a result of the separate collection program, Marblehead was able to change its collection frequency to once a week in May 1977 and to eliminate one of its four crews and one of its refuse-collection vehicles.

During 1977 Somerville received a total of $10,938 for the sale of its recycled materials and saved $14,456 by avoided landfill costs. Marblehead obtained $25,540 for its recycled materials and saved $41,084 through avoided disposal costs. (14)

Program costs and savings for both Somerville and Marblehead in 1977 were as follows:*

Somerville: Spent $146,470 for recycling program. However, some of the costs of personnel and equipment from the refuse-collection program could be transferred. Thus actual costs to the city were $80,122.

Somerville's program showed a net loss of$12 1,076 on a "full-cost" basis (full cost of labor, equipment, and consumables used in recycling service: reflects recycling budget), and a loss of $54,728 on an "actual-cost" basis (additional costs actually incurred by community due to recycling program).

Marblehead: Spent $90,394 for its multimaterial program, Actual costs, however, were $49,836.

Marblehead's program showed a net loss of $23,760 on a full-cost basis, but a net gain of $16,788 on an actual-cost basis.

*The cost figures are based on reference (17).

The multimaterial program in Andover, Mass., which collects residential newspaper, glass, and cans, showed a net additional cost of $3.22 per ton recovered by source separation ($0.56 per ton of waste managed). However, the cost analysis was based on newspaper revenues of $15 per ton, and an increase to $20 per ton would have allowed the program to break even. The Andover program covers a population of 26,000 that generates 57'9 tons per month of solid waste. A total of 101 tons per month of glass, cans, and newspapers were separately collected, for a recovery rate of 17.4 percent based on residential waste only. (Participation rates are much greater than 17 percent.)

Multimaterial Recovery in Community Recycling/Reclamation Centers

Another approach to source separation is through multimaterial community recycling centers. These differ from separate collection programs in that the participant is required to deliver waste materials to a central collection point. During the late 1960's, as environmental awareness spread, thousands of collection centers for recyclable were set up in the United States.

Just as with other source separation approaches, however, there must be an awareness of the interplay between adequate markets, the high cost of transporting recycled materials, the level of participation, and the program's success. Startup and operating costs are relatively low for recycling centers compared with those for high-technology resource recovery plants, and the quality of the materials recovered can be high because they are handsorted by residents, (Supervision may be needed to assure that components are not contaminated both when they are dropped off and during their processing.)

A community recycling center can be sponsored by a municipality or by a private contractor, and can be run on either a mandatory or a voluntary basis. While most centers give local residents the opportunity to recycle a portion of their mixed refuse, they do not pay for recycled materials. Many of the centers, particularly those in rural areas, recover material in the solid waste stream that would otherwise be lost. The closing of open dumps, as required by the Resource Conservation Recovery Act, may increase the value to a community of a recycling center because the amount of mixed waste headed for its landfill or incinerator is reduced.

In New Hampshire, the towns of Plymouth, Nottingham, and Meredith, have multimaterial community recycling centers that combine recycling with incineration of nonrecovered mixed refuse. Recycling newspapers, clean mixed paper, glass, metal, and other rubbish is mandatory in both Plymouth and Nottingham. Plymouth also recovers corrugated paper. Meredith only requires separating glass from the rest of the waste stream.

Each of the towns sorts and processes its recycled materials differently. In Nottingham, glass is color sorted and the caps and rings are removed from glass bottles. Once sorted, the glass is mechanically crushed and transported to market. Both Plymouth, which color sorts some of its glass, and Meredith, which does no sorting, have their recycled glass picked up at the centers by its purchasers. Plymouth and Nottingham mechanically flatten recovered cans, and in all the systems the recovered corrugated paper and newspapers are baled.

The participation of residents ranges from about 95 percent in Nottingham and Plymouth, which have mandatory programs, to 25 to 50 percent in Meredith. Town officials feel that when a "substantial" portion of the waste stream is recovered through recycling, net costs are lower than they would be for any other environmentally acceptable system that does not involve recycling.

Multirnaterial Recovery in Industry Sponsored Recycling Programs

Source-separated materials are also recovered by industry-sponsored recycling centers in programs that vary from recovering only one material such as aluminum to multimaterial recycling. Unlike community-sponsored recycling programs, industry programs pay participants for recycled materials.

One multimaterial recycling program, the Beverage Industry Recycling Program (BIRP), has been operated throughout Arizona by the beverage industry since 1971. It has 10 recycling centers (3 more are in the planning stage) that accept aluminum and steel cans, newspapers, and corrugated paper. During 1977, 15,227 tons of materials were recovered, an increase of 70 percent, over 1976. (This is about 1 percent of Arizona's total waste load.) Participants were paid $2,390,000, an increase of 82 percent. BIRP also has a number of recycling centers in various stages of development in New Mexico.

Recycling centers that recover one material, aluminum, are operated by aluminum and beverage companies, which pay 15 to 17 cents per pound (about 23 cans). The first aluminum can recycling centers were opened in 1967. As of May 1978 there were 2,300 collection points. The cans are collected at both mobile and stationary centers and are shipped to secondary smelters.

The Aluminum Association estimated that in 1977 about 6.4 billion cans weighing 140,000 tons were returned for recycling. (In 1976, 1,312,006 tons of aluminum were recycled from all sources.) Reynolds Metal Company representatives forecast that in the absence of beverage container deposit legislation from 30 to 50 percent of the aluminum cans produced will be recycled by 1980 and from 50 to 70 percent by 1985.(22) With a national beverage container deposit law, higher recycling percentages would be anticipated, but containers would be recovered through the deposit system, (See chapter 9.)

Wastepaper Recovery Through Office Recycling Programs

Many companies and Government agencies separately collect high-grade wastepaper from offices. This wastepaper, called "white ledger," consists of letterhead, dry copy paper, business forms, stationery, typing paper, tablet sheets, and computer tab cards and printout papers. Computer tab cards, which have a very high value, are usually boxed separately at computer centers and recycled.

The most successful method used in recycling wastepaper from offices is called the "desktop" program. A container is placed at each desk for high-grade wastepaper, which is periodically collected and taken to a central location to be baled and shipped to market. The EPA reports that in 1976, 450 organizations were participating in one recycling company's desktop office paper collection program—60 percent more than in 1975.(23) Approximately 100 Federal Government buildings, housing 125,000 employees were participating in such programs by October 2, 1978.(24) In addition, some 20 State governments, numerous cities, and the Canadian Government have all adopted this program.

An EPA-funded study of 12 private office wastepaper collection programs found a 12-percent average reduction in net solid waste management costs. Cost savings were greatest in programs that only recover white, high-grade paper. Costs included publicity, equipment, and labor. Participation averaged 80 percent for the programs studied, and ranged as high as 95 percent.

Commercial and Industrial Methods of Source Separation

Over the past few years, supermarkets, shopping malls, airports, hospitals, private businesses, and industrial facilities, such as auto assembly plants, have source separated such products as corrugated paper. The method used depends on the amount of paper generated, the space available for storage, and the investment required.

Data being prepared under contract for EPA indicate that most corrugated paper recovery takes place locally through neighborhood supermarket chains. For example, Safeway Stores, Inc., a national chain of supermarkets, is source separating the corrugated portion of its waste stream at most of its stores. One regional division, with 165 stores in Pennsylvania, Delaware, Maryland, northern Virginia, and Washington, D. C., source separated 23,000 tons of corrugated paper in 1977. This material was baled on site and sold to private haulers.

The same study found that large airports; shopping malls, hospitals, and commercial establishments were beginning to source separate their waste. Airports recover ferrous metals, while hospitals and shopping malls mainly recover corrugated paper. Most of the material recovered by commercial establishments was found to be high-grade paper.

Marketing Recovered Materials

The marketability of recovered materials must be taken into account by communities that undertake recycling programs. Both cans and glass, as well as some wastepaper, need to be upgraded by cleaning, sorting, and other processing in order to meet market specifications. Local communities that sponsor curbside recycling programs are faced with the decision of processing the materials themselves or selling their recycled materials to intermediate processors, which are firms that purchase glass and cans from local communities and prepare them for the final market. Most communities are not doing the processing themselves.

The EPA's national survey of separate collection programs found that 39 percent of the programs surveyed had contracts with materials dealers or manufacturers to sell their recycled materials. Most of these contracts were for newspapers and mixed wastepaper and covered a period of 1 (75 percent) to 3 or more years. Other contract stipulations varied from those with both a floor price and a floating price above the floor price to those having only fixed-price provisions.

The price for recycled newspapers and mixed wastepaper has fluctuated throughout the history of separate collection programs. EPA found that during the 1974-75 recession, separate collection programs were seriously affected. Many were discontinued. Those communities that continued the programs reported that the price for recycled materials had been reduced.

A detailed discussion of the issues and problems related to marketing recycled materials can be found in the marketing section of chapter 3.

Interaction of Source Separation and Other Policies

Source Separation and Beverage Container Deposits

Source separation and beverage container deposits are both designed to reduce the amount of high-quality used products that get thrown away. An interesting consideration is whether establishing both approaches in the same region might detract from the attractiveness of either of them. Put another way, should source separation and beverage container deposits be viewed as competing or complementary?

Source separation and mandatory beverage container deposits might interact in several ways. A successful beverage container deposit law would reduce the glass and metal content of the solid waste stream and consequently the potential revenues from source separation would be reduced. A successful beverage container deposit law, however, would recover largely green and amber glass, leaving clear glass from food containers to be recovered by other means. Thus, a source separation program might recover only clear glass, which would have a higher market value than would a mixed-glass fraction containing green and amber glass as well.

If a residential source separation program is established, consumers who have returned beverage containers for environmental and conservation reasons may become less likely to do so. They may decide that separate collection is an acceptable alternative to landfill, even though glass bottles recovered in a curbside source separation program are likely to be broken and not reusable. Consumers who are motivated to return containers in response to the financial incentive of a deposit system are likely to continue to do so even if a source separation program is established.

In this analysis, it is assumed that, on balance, a source separation program will not affect the return rates and market shares for containers. Therefore, the focus is on the reduction in potential revenues from source separation if beverage container legislation is implemented.

The effect that beverage container deposit legislation (BCDL) might have on potential source separation revenues is estimated in the following way. In chapter 9, five scenarios are presented for the performance of the beverage delivery system under mandatory deposit legislation. Scenario I represents the actual situation in 1975. Changes in MSW composition are estimated for four other sets of return and recycle rates and market shares for containers, assuming that BCDL had been fully implemented in 1975. These estimates are used here to evaluate the impact of BCDL on potential source separation program revenues in 1975 for each of the four scenarios, assuming a 50-percent participation in source separation for each component of the waste, and assuming average revenues per ton of the recovered material. *

Table 26 summarizes the calculation of potential revenues and credits from source separation using the five BCDL scenarios. (This table presents only revenues and not the effects of BCDL on the cost of separate collection, which would be small). For the base case without BCDL, the potential revenues and credits total $8,36 per ton of waste generated. Each of the four other scenarios shows a reduction in revenues and credits. The revenues and credits with BCDL range from $7.58 to $7.81 per ton, for a reduction of 7 to 9 percent in revenues and credits per ton of waste generated. Since total waste tonnage decreased by as much as 3.6 percent, total revenues and credits might decrease by as much as 13 percent.

These reductions in source separation revenue with BcDL are relatively small because the contribution of container materials to revenues is, at most, only $2.29 per ton of generated waste. Beverage containers represent only a fraction of this, and BCDL is not expected to remove all beverage containers from MSW under any circumstances. ln fact, container revenue drops no lower than $1.41 per ton under any scenario.

Finally, it should be noted that the four BCDL scenarios span a wide range of system response from an all-glass-refillables system to a system with a high can-market share. Should BCDL be ineffective and return rates be very low, potential source separation revenues might remain the same or actually increase.

The preceding analysis is based on the adoption of a comprehensive residential and commercial source separation program. For a program limited to residential source separation, the impact of deposit legislation on source separation revenue would be more significant. Based on the data in table 24, a program picking up only newspapers, glass, and metal cans has a potential revenue of $3.35 per ton of generated waste without a deposit law and $2.51 to $2.75 per ton with a law. The maximum difference of 84 cents per ton of MSW generated corresponds to a drop in the potential gross revenue of 25 percent.

Source Separation and Centralized Resource Recovery

Source separation removes a fraction of materials from the waste stream. It may therefore reduce the potential revenue of an existing resource recovery plant. On the other hand, an effective source separation program can reduce the volume of waste to be disposed of and thus allow a smaller resource recovery plant to be built, while simultaneously reclaiming some resources of higher quality and value (particularly paper fiber, which, in many cases, has a higher value as a raw material than as a fuel).

The local economics of source separation and centralized resource recovery should be carefully investigated in order to judge whether either approach alone, or some combination of both, would be the most attractive. ** Nevertheless, some insight into the revenue and resource recovery implications of a dual system can be gained by examining the following example.

*For all the scenarios it is assumed that the components of MSW other than beverage containers are the gross discards (waste as discarded before recycling) presented in table 4. For Scenario I, the actual situation in 1975, beverage container waste components available for source separation are assumed to be included in the gross discards. For the four scenarios under BCDL, the beverage container waste components available are assumed to be the “net waste disposed of” because the remainder are returned through the deposit channel for reuse or direct recycling. In each case, the percentage composition of the waste is adjusted to reflect the new totals.

**The question of Compatibility between source separation and centralized resource recovery systems is currently being examined in detail by EPA in response to section 8002(e) of the Resource Conservation and Recovery Act of 1976.

Table 26.—Impact of Beverage Container Deposit Legislation on Potential Source Separation Revenues for Five BCDL Scenarios (Basis: 1975 and 50-percent participation)

Material	Potential unit revenue[a] ($/ton)	Potential source separation revenue per ton of waste generated at 50-percent participation for each scenario ($/ton)				
		I	II	III	IV	V
Newspaper	32.50	1.06	1.07	1.11	1.09	1.09
Books and magazines	12.50	0.14	0.14	0.15	0.15	0.14
Corrugated paper	30	1.38	1.40	1.43	1.43	1.41
Office paper	97.50	1.85	1.90	1.95	1.90	1.90
Glass containers	25	1.15	1.18	0.90	0.73	1.00
Steel containers	30	0.60	0.47	0.48	0.51	0.48
Aluminum containers	300	0.54	0.03	0.03	0.18	0.17
Yard waste	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
Total major source-separable materials revenues	—	6.72	6.19	6.05	5.99	6.19
Credit for disposal avoidance	6	1.64	1.62	1.58	1.59	1.60
Total revenues and credits	—	8.36	7.81	7.63	7.58	7.79

[a]Average of values in table 23.
[b]In this report recovery of yard waste in source separation programs is assumed to produce only landfill credits and neither energy savings nor net revenues. This choice is made because yard waste is quite varied seasonally and geographically and because experts disagree widely about the viability of yard waste utilization or sale. The effects of this choice are to underestimate by a small amount the economic and energy potentials of source separation.

Suppose that each person in a city with a population of 500,000 discards 3.5 pounds per day of MSW which has the national average composition. The city is considering three resource recovery options:

1. Construction of a centralized resource recovery plant to recover materials and refuse-derived fuel (RDF).
2. A multimaterial residential and commercial source separation program that recovers each of the materials included in table 21.
3. A combination of 1 and 2.

Estimates of materials and energy recovery and of revenues are summarized for each option in table 27. (It should be noted that this table only presents gross revenues and does not present the effects of various options on collection costs.)

Under option (l), an RDF plant with an average daily capacity of 875 tons is required. It would produce average daily revenues and disposal credits totaling $14,085.

Under option (2), if 50-percent participation occurs, a source separation program recovers 239 tons per day of materials and produces daily revenues and credits of $7,381.

Under option (3), if 50-percent participation in source separation occurs, an RDF plant with a daily capacity of 636 tons is needed. This option will produce combined revenues and disposal credits of $17,116, or $3,031 more than for option 1. At a processing cost of $15 per ton (see table 46), daily RDF processing costs are $3,585 less for the combined system than for the RDF system alone. If the additional costs for operating the source separation program are less than $6,616 per day ($3,031 plus $3,585) the combination in Option 3 is economically preferable to centralized resource recovery alone. Note that $6,616 per day is equivalent to $7.56 per ton of MSW collected and that source separation is generally thought to cost less than this to implement.

The input data for these comparisons are estimates and the results are by no means definitive. In addition, table 27 assumes that the technologies listed work, that the participation rate needed in Options 2 and 3 is achieved, and that there are markets for the

Table 27.—Recovery Rates and Revenues for Three Resource Recovery Option

Impact measure	option 1 RDF & materials	Option 2 source separation	Option 3 combination
RDF facility size (tpd).	875		636
Ferrous recovery (tpd)		18	67
Aluminum recovery.	: ;	1.8	4.1
Glass recovery (tpd).		40	
Nonferrous recovery (tpd).	0⁴;6		0.766
Paper recovery (tpd).		:	96
Yard waste recovery (tpd)	:	84	84
RDF productionc(tpd)	834	0	
RDF production (10* Btu\d).	7.88	0	454
Materials revenues ($/day).	3,693	5,947~	8,603e
Energy revenues ($/day).	5,910	0	3,893
Landfill credits ($/day @ $6/ton)	4,482	1,434	4,620
Total revenue & credits ($/day)	14,085	7,381	17,116

[a]Average unit revenues for source separation from table 26. Average unit revenues for centralized resource recovery from table 11. Recovery efficiencies for RDF system are: ferrous, 90%; aluminum and glass, 50%; nonferrous, 30%.
[b]Participation rate 50% in source separation.
[c]Heating value of RDF is 6,210 Btu per pound under Option 1 and 5,716 Btu per pound under Option 3, for a decrease of 8 percent.
[d]Assumes source separated paper and yard waste have heating values of 7,500 Btu per pound.
[e]Assumes no revenue for recovered yard waste.

materials recovered, Nevertheless, the table suggests that a combination of source separation and centralized resource recovery is on an almost equal, if not better, economic footing than centralized resource recovery alone. If this is true, there is no reason for a community to reject the possibility of a well-integrated source separation and resource recovery program on economic grounds, Furthermore, the joint program will require a lower total capital investment, and will produce revenues from the source separation program and reduce landfill costs almost immediately while construction of the resource recovery plant proceeds. In addition, source separation material revenues may grow more rapidly than those from centralized resource recovery owing to their higher quality. Of course, the success of resource recovery, either through centralized resource recovery or through source separation is highly dependent on the availability of existing markets for the recovered materials.

The analysis also makes clear that the resource recovery plant revenues would be smaller with source separation in place and that part of the revenues from the source separation program would have to pay for the higher net unit cost of resource recovery. A preexisting resource recovery plant designed to process the entire city's waste would experience a sharp decline in revenue if a source separation program were successfully introduced after the plant was built. For example, an RDF plant that depends on a large amount of burnable wastepaper might be severely affected by a source separation program that recovered newspapers and/or mixed wastepaper.

Source Separation and Economic Incentives

Source separation would be stimulated if the Federal Government implemented economic incentives to encourage recycling. Such incentives might include the establishment of a "product charge" on all products entering the municipal waste stream, modification or repeal of the percentage depletion allowance, and/or the institution of a Federal income tax credit for the purchase of recycled materials. These options are mechanisms to increase the demand for recycled materials by the producers of primary materials. As a consequence, a wide range of recycling activities, including source separation, would be encouraged. (See chapter 8 for a discussion of these economic incentives and their effectiveness in stimulating recycling and reducing the rate of waste disposal.)

Federal Policy and Source Separation

Source separation can be a desirable local or regional approach to recovering a portion of the solid waste stream. It is, therefore, of interest to consider the policy options available to the Federal Government for implementing or improving this approach. Such options should permit a range of responses at the State and local levels so that the different roles that source separation could play under various circumstances would be recognized.

No Additional Federal Action

In the limited number of cases for which data are available, source separation appears to be self-sustaining, or nearly so, on an economic basis. Thus, there may be little need for Federal action, other than assuring that Federal agencies consider source separation, along with centralized resource recovery, as a viable component of solid waste management systems. In designing general policies toward solid waste management and materials conservation, Federal agencies should not arbitrarily rule out source separation approaches. For example, planning, demonstration, or financial incentive programs should include source separation along with centralized resource recovery.

Direct Federal Action

MANDATED SOURCE SEPARATION OF MATERIALS BY FEDERAL AGENCIES

The EPA issued guidelines in 1976 requiring separate collection of paper at any Federal agency that generates recoverable paper wastes, under the authority of section 209(a) of the Solid Waste Disposal Act, as amended by the Resource Recovery Act of 1970. The guidelines are recommended to State and local governments as well as to private organizations. They require that Federal office buildings with a minimum staff of 100, source-separate and recycle high-grade paper; that Federal facilities (such as military bases) housing 500 or more families recycle newspapers; and that corrugated containers from Federal facilities that generate 10 or more tons per month must be recycled.

INCENTIVES FOR INVESTMENT IN RECYCLING FACILITIES

Another option is to provide interest rate subsidies, cash grants, or other incentives to public agencies or to private firms for investment in recycling facilities. (See chapter 2 for a discussion of the additional 10-percent investment tax credit for recycling facilities passed into law in late 1978.) Intermediate processing industries for source-separated material would be included as candidates for such incentives. Proposals have been made for a bank that would lend funds for recycling facilities at 1 percent above the cost to the Government of lending the money. Such a proposal would help reduce interest rates on such loans thereby making investments in recycling facilities more attractive.

LABOR TAX CREDITS FOR RECYCLING PROGRAMS

A corporate income tax credit for some portion of the wages of additional employees hired to carry out recycling activities might stimulate all types of recycling. Such a program would tend to favor private sector source separation over centralized resource recovery because separate collection is more labor-intensive than other kinds of recycling.

FEDERAL SUPPORT FOR RESEARCH, DEVELOPMENT, AND DESIGN FOR SOURCE SEPARATION

Another option is to fund research, development, and design for source separation. Examples of possible project areas are: (a) developing well-documented educational material to be used in informing communities about source separation, (b) designing manuals to be used by communities or offices in setting up source-separation recycling programs, (c) developing mechanisms for motivating high participation rates for source separation, and (d) devising ways to improve the removal of contaminants from wastepaper, glass, and cans.

FEDERAL FUNDING OF DEMONSTRATION PROJECTS

Funding for demonstration projects is another option available to the Federal Government. Such grants can be used to: (a) learn more about a particular new program, product, or process—"policy-formulating demonstrations;" (b) promote the use of a program, product, or process—"policy-implementing demonstrations;' and (c) provide a political compromise between those groups that prefer large-scale operating programs and those that prefer nothing.

Demonstration grants could improve a number of areas in the field of source separation. A major demonstration program is needed in a large eastern city, which would focus on collection, public awareness, processing/marketing, and waste utilization techniques. The purposes of such a program would be to test both the viability of source separation in a major metropolitan area and its interaction with other solid waste management options. Demonstration grants might also be provided to the intermediate processing industries in order to develop improved methods for removing contaminants from wastepaper, glass, and cans.

Currently EPA is sponsoring a demonstration grant to the Denver Regional Council of Governments for implementing a source separation program in Boulder, Colo. Other implementation grants previously sponsored by EPA included programs in Somerville and Marblehead, Mass., in Nez Pez County, Idaho, in Duluth, Minn., and in San Luis Obispo and Modesto, Calif,

Indirect Federal Action

FEDERAL PROCUREMENT

The Federal Government's expenditures on paper and other goods, while large, are small in comparison to those of the private sector. However, many procurement practices of the Federal Government are widely adopted by States, local municipalities, and industry. Consequently, a modification of Federal procurement specifications and procurement practices to require recycled paper or other goods will have a positive effect on the use of these recycled materials. Specifications that encourage greater use of recycled paper would stimulate demand for source separation programs, since recyclable paper can be produced from wastepaper only if it is kept separate from mixed MSW.

Section 6002 of the Resource Conservation and Recovery Act (RCRA) specifies that Federal agencies will be required to choose products that are composed of the highest percentage of recycled materials practicable, consistent with maintaining a satisfactory level of competition, after October 21, 1978. However, in developing guidelines in response to the Act, EPA has had difficulty in precisely defining a "recycled" material. The RCRA only defines a "recovered" material. It does not explicitly define the term "recycled. " As a result EPA is working to develop guidelines that will define, in some detail, the Act's intent with respect to the use of home scrap, prompt scrap, and postconsumer scrap in the recycling process.

At present, EPA is trying to tie the date for compliance by the Federal agencies to the issuance of its guidelines. This action requires that an amendment to RCRA changing the October 21, 1978 compliance date be passed, or that an oral agreement be reached between the affected Federal agencies and Congress. EPA's proposed guidelines are expected to be phased-in during FY 1978 and FY 1979. Four sets of guidelines will be issued so that industry's specific questions about what constitutes a "recycled" material can be answered in detail. The guidelines will be broken down into the following categories: (i) paper products, sanitary paper, computer paper, etc.; (ii) fly ash used in the manufacture of cement; (iii) other construction materials; and (iv) composted sewage sludge.

OTHER INDIRECT FEDERAL ACTIONS

A number of other incentives that could be adopted by the Federal Government to encourage recycling would stimulate source separation. These include: (i) establishment of "product charges" on all products entering the municipal waste stream; (ii) elimination of the capital gains tax treatment of income from timber sales; (iii) equalization of freight rates for virgin and secondary materials; (iv) modification or repeal of the percentage depletion allowance; (v) placement of a tax on virgin materials levied at the point of mining or harvest in proportion to some measure of the amount or value extracted, i.e., a severance tax; and (vi) a Federal income tax credit for the purchase of recycled materials. None of these options is unique to source separation. However, they are all possible ways to stimulate a wide range of recycling activities, including source separation, by increasing the demand for recycled materials by the producers of primary materials. These options are discussed in detail in chapters 3 and **8.**

Findings on Source Separation

Source separation for the recovery of recyclable materials from MSW is widely practiced in the United States today. It is the only available method with which wastepaper can be recovered for recycling into new paper products. It is also used to recover glass, ferrous and nonferrous metals, and yard waste for recycling. Nearly all of the MSW that is currently recovered for recycling is collected in source separation programs.

Source separation can produce sizable revenues and energy savings from MSW, but has only a limited effect on the total solid waste stream. For example, at 50-percent participation, a comprehensive residential and commercial program could recover around one-fourth of a community's MSW, leaving three-fourths for recovery or disposal by other means. With such a program in place, a community would still have ample opportunity to install a centralized system for materials and/or energy. Depending on the level of participation and on market conditions, a carefully planned combination of source separation and centralized resource recovery may be the optimal approach from an economic point of view.

Source separation programs currently operated by municipalities, industry, and volunteer groups include curbside separate collection programs, multimaterial recovery in community recycling centers, industry-sponsored recycling programs, and commercial and industrial methods of source separation. According to EPA, about 133 communities were collecting newspapers in curbside programs in May 1978. Another 40 were collecting other kinds of paper and/or glass and cans. Industry-sponsored programs collected 24.8 percent of all-aluminum beverage cans produced in 1977.

Although source separation has grown in popularity in the last decade, some programs have experienced technical or organizational problems. Many others, however, have failed owing to problems in marketing their products, and still others have faced indifference or hostility from proponents of alternative approaches. Nevertheless, a great deal of expertise has been developed for designing and operating such programs. Much of the activity has occurred in small towns and in moderate-sized cities. A residential source separation program encompassing a major urban area has yet to be demonstrated.

Nearly every potential Federal action to encourage recycling would stimulate source separation activities, unless specific barriers to its inclusion are raised. Specific Federal efforts to assist source separation activities would include funding of systems research, innovative program design, and improvement of equipment for intermediate processing or materials upgrading. One important option would be for Federal assistance to demonstrate curbside source separation in a major urban area in order to learn how to implement such a program, and, presuming success, to show other cities what might be done.

Finally, there are no major inherent conflicts among source separation. centralized resource recovery. and beverage container deposit legislation. However, to avoid possible revenue problems, capital-intensive, centralized systems must usually be designed to accommodate existing or future separate collection programs.

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References

1. Cohen, David M., Separate Collection Programs: A National Survey, U.S. Environmental Protection Agency, 1978, p. 8.
2. Gordian Associates Incorporated, Environmental Impacts of Production of Virgin and Secondary Paper, Glass, and Rubber Products, Final Report (SW-128c) for the U.S. Environmental Protection Agency, 1976,
3. Ziegler, R. C., S.M. Yaksich, R.P. Leonard, and M. VanLier, Environmental Im pacts of Virgin and Recycled Steel and Aluminum, Final Report (SW-117c) done by Calspan Corporation for the U.S. Environmental Protection Agency, 1976.
4. Bravard, J. L., H. B. Flora, and C Portal, Energy Expenditures Associated With the Production and Recycle of Metals, Oak Ridge National Laboratory Report ORNL-NSF-EP-24, November 1972.
5. Cohen, David M., op. cit., pp.1 and 3.
6. Fremont Public Association and Fremont Recycling Station No. 1, Seattle Recycling Project Final Report 1977: A Pilot Study of Voluntary Source Separation Home Collection Recycling, performed for the City of Seattle, Department of Human Resources, pp. 3-22.
7. League of Women Voters Education Fund, Final Report on Training Grant T900604-01-0 Between the Office of Solid Waste, U.S. Environmental Protection Agency and the League of Women Voters Education Fund, 1977.
8. Cohen, David M., op. cit., p. 47
9. Ibid., p. 1.
10. Ibid., p. 16.
11. Ibid., p. 47.
12. Conversation with T. Jagelski, Division of Engineering, Department of Public Works, Madison, Wis., Jan. 3, 1978.
13. Cohen, David M., op. cit., p. 1.
14. Unpublished memorandum from Stephen E. Howard to Penny Hansen, Status of Glass Recovery and Marketing Through Source Separation in the Northeast Corridor, U.S. Environmental Protection Agency, Washington, D. C., July 26, 1978, p. 2.
15. U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, Resource Recovery and Waste Reduction, Fourth Report to Congress, EPA Publication SW600, Washington, D. C., U.S. Government Printing Office, 1977, pp. 35-37.
16. Resource Planning Associates, Inc., Solid-Waste Recovery Programs in Somerville and Marblehead, Massachusetts, Monthly Reports: January 1977 Through December 1977, Draft Report prepared for the U.S. Environmental Protection Agency, Jan. 20, 1978, p. 1.
17. Ibid., p. 2.
18. Monthly Solid Waste Management Costs, Andover, Mass., Oct. 27, 1977. Researched by Steve Howard, Office of Solid Waste Management Programs, U.S. Environmental Protection Agency, presented at a Source Separation Conference in Newton, Mass., October 1977.
19. Jansen, Edmund F., Jr., and Richard Tichenor, Recycling as an Approach to Solid Waste Management in New Hampshire: An Overview of Five Systems, New Hampshire Agricultural Experiment Station, University of New Hampshire, Durham, N. H., in cooperation with Recycling and Conservation, Inc., Kittery, Maine.
20. Data based on conversation with Jane Gallagher, staff member of Beverage Industry Recycling Programs (BIRP) in Phoenix, Ariz., October 1978; and Resource Recovery Report, vol. 2, No. 4, March 1978, p. 3.
21. Data provided through conversation with Diane Simmons, Aluminum Association, Washington, D. C., October 1978.
22. Conversation with G. Bourcier, Manager of Resource Recovery Programs, Reynolds Metals Company, October 1977.
23. U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, op. cit., p. 38.
24. Data based on conversation with Chas. Miller, U.S. Environmental Protection Agency, Office of Solid Waste Manage-

ment Programs, Washington, D. C., Oct. 5, 1978.
25. U.S. Environmental Protection Agency, Resource, Recovery, and Waste Reduction, op. cit., p. 39.
26. Data obtained through conversation with Ester Bowering, SCS Engineers, October 1978.
27. Data obtained through conversation with Ernest Moore, Public Relations Manager, Washington Division, Safeway Stores, Inc., October 1978.
28. F.R. 41, No. 80, 16950-16956, Apr. 23, 1976.
29. Office of Technology Assessment, R&D Program, The Role *of* Demonstrations in Federal R&D Policy, U.S. Congress, Washington, D. C., U.S. Government Printing Office, 052-003-00557-3, OTA-R-70, pp. ix-x.
30. Data based on conversation with John Heffelfinger, U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, Washington, D. C., January 1979.

Chapter 15

Technologies for Centralized Resource Recovery

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Tables

CHAPTER 5

Technologies for Centralized Resource Recovery

Introduction and Issues Addressed

Centralized resource recovery includes any process that can recover energy and/or recyclable materials from collected, mixed municipal solid waste (MSW). These processes are listed in table 28. In complexity they range from simple recovery of ferrous materials using magnets to complex systems that include the production of liquid or gaseous fuels by pyrolysis and the recovery of ferrous metals, aluminum, glass, and other nonferrous metals. While centralized resource recovery is sometimes viewed as being in the class of high-technology aerospace spinoffs, it includes small-scale modular incineration, simple mechanical processes such as shredding, and such biological processes as comporting and anaerobic digestion.

Table 28.—Municipal Solid Waste Energy and Materials Recovery Systems

Energy recovery systems
Mass combustion of raw MSW
Waterwall incineration
Small-scale modular incineration with heat recovery
Refuse derived fuel (RDF)
Dry processes
Fluff RDF
Dust or powdered RDF
Densified RDF
Wet processes
Pyrolysis systems
Low Btu gas
Medium Btu gas
Liquid fuel
Biological systems
Landfill methane recovery
Anaerobic digestion
Hydrolysis
Materials recovery systems
Comporting
Ferrous metals
Aluminum
Glass
Fiber
Wet separation
Dry separation
Nonferrous metals

SOURCE Off Ice of Tecnology Assessment

In this chapter the following questions and issues are addressed:

- What centralized resource recovery technologies are available?
- What is the status of these technologies and how well do they perform the tasks of waste disposal and resource recovery?
- What environmental, health, and safety problems may exist or emerge with centralized resource recovery?
- How does the question of plant size or , scale affect decisions about centralized resource recovery systems?
- What should be the Federal role in meeting research, development, and demonstration needs?

In this chapter, the status of the technologies and their effectiveness in resource recovery and waste reduction are examined. Issues related to environmental and workplace health and safety, the question of scale in resource recovery systems, and the Federal role in research, development, and demonstration are addressed. Other issue-oriented questions regarding markets, economics, institutional problems, and selection of overall waste management strategies are discussed in other chapters.

The technologies listed in table 28 are described briefly in appendix C. More technical detail is available in the additional readings listed at the end of appendix C.

The problem of technology selection and system design to serve a particular community is a difficult one, It requires consideration indepth of local conditions and of technological capabilities. The purpose of this report is not to provide sufficient detail to make such local decisions but only to assist in making the policy decisions associated with resource recovery programs.

Status of the Technologies

This section includes an inventory of resource recovery facilities in the United States. The various technologies are then compared in terms of (i) degree of proven commercialization, (ii) waste reduction efficiency, (iii) material recovery efficiency, and (iv) energy recovery efficiency. Estimates are presented of the maximum potential energy savings from the recovery of energy and materials from MSW. Finally, information on the status of European systems is reviewed.

Inventory of Centralized Resource Recovery Facilities in the United States

Table 29, which lists centralized resource recovery facilities now operating or under construction in the United States based on a recent Environmental Protection Agency (EPA) publication,(l) is an update of an earlier table published by EPA in 1976 in its Fourth Report to Congress.(2) It lists 17 plants in operation (down from 21 in 1976) with a total capacity of 6,730 tons per day (tpd) (down from 9,880 in 1976). The main differences between table 29 and the earlier EPA table are the addition of Baltimore and Baltimore County, Md., and Milwaukee, Wis., to the operational list; the deletion of experimental facilities in St. Louis, Me., and Washington, D, C.; and the deletion of five waste incinerators in Chicago, Ill., (two plants), Harrisburg, Pa., Merrick, N. Y., and Miami, Fla.

Table 29 also lists 12 facilities in startup or under construction (up from 10 in 1976] with a total capacity of 11,860 tpd (down from 12,560 in 1976). The major differences in this category include shifting Baltimore, Baltimore County, and Milwaukee to the operational list; adding Akron, Ohio,; Bridgeport, Corm.; Lane County, Oreg.: Monroe County and Niagara Falls, N. Y.; and North Little Rock, Ark.; and deleting the 6,000-tpd proposal for St. Louis.

In the Fourth Report to Congress,(2) EPA listed a number of communities engaged in various stages of planning for centralized resource recovery. Since 1976, neither EPA nor OTA has updated this list. Subsequent events suggest that it is not a reliable guide to the current situation nationwide.

In October 1978, the Department of Energy (DOE) announced that 20 communities would receive grants to conduct studies for demonstrating the feasibility of recovering energy from waste.(3) None of these grants is to be used for construction purposes.

It is difficult to classify the operational status of the facilities in table 29 because many of them are experimental or demonstration facilities whose status can change quickly. The term "operational" does not necessarily mean "commercial. " Several of the facilities in the operational phase have been based on significant public or private subsidy. Others are similarly subsidized demonstration plants. The San Diego County pyrolysis facility is shut down for major modification.(4)

Table 29 shows a trend toward large-scale plants among those under construction or in startup. Over half have a capacity of 1,000 tpd or more. A possible shift away from this early trend toward building large plants is discussed in this chapter. The table also shows that the most popular systems are waterwall incineration and refuse-derived fuel (RDF), but that there is interest in small modular combustion units such as those in

Table 29.– Resource Recovery Facilities in the United States

Location	Type'	Capacity (tons/day)	Products/markets	Startup date
In operation:				
Altoona, Pa.	Compost	200	Humus	1963
Ames, lowa.	RDF	400	RDF-utility, Fe,Al	1975
Baltimore, Md. (D)	Pyrolysis	700	Steam heating&cooling. Fe	1975
Baltimore County, Md. (D).	RDF	550	RDF,Fe,ALglass	1976
Blytheville, Ark.	MCU	50	Steam process	1975
Braintree, Mass..	WWC	240	Steam process	1971
E. Bridgewater, Mass. (D)	RDF	160	RDF-utility	1974
Franklin, Ohio (D).	Wet pulp	150	Fiber, Fe. glass, Al	1971
Groveton, N.H.	MCU	30	Steam process	1975
Milwaukee, Was.	RDF	1,000	RDF-utility, paper Fe, Al	1977
Nashville, Term.	WWC	720	Steam heating & cooling	1974
Norfolk. Va.	WWC	360	Steam (Navy base)	1967
Oceanside. N.Y.	RWI/WWC	750	Steam	1965/74
Pales Verdes, Cal if.	Methane recovery		Gas-utility & Fe	1975
Saugus. Mass.	WWC	1,200	Steam process	1976
Siloam Springs, Ark.	MCU	20	Steam process	1975
South Charleston, W. Va.(D)	Pyrolysis	200	Gas. Fe	1974
Under construction; startup:				
Akron, Ohio	RDF/WWC	1,000	Steam heating & cooling	1978
Bridgeport.Corm.	RDF	1.800	RDF utility. Fe, Al, glass	1978
Chicago, ill.	RDF	1,000	RDF-utility, Fe	1976
Hempstead, N.Y.	Wet pulp/WWC	2,000	Electricity, Fe. Al, glass	1978
LaneCounty, Ore.	RDF/WWC	750	RDF-institution, Fe	1978
Monroe County, N.Y.,	RDF	2.000	RDF-utility. Fe, Al, glass	1978
Mountain View.Calif (D).	Methane recovery		Gas/utility	1977
NewOrleans, La.(D)	Materials	650	Nonferrous, Fe, glass, paper	1976
Niagara Falls, N.Y...	RDF/WWC	2,200	Steam industry, Fe	—
North Little Rock, Ark.,.	MCU	100	Steam process	1977
Portsmouth, Va..	WWC	160	Steam loop	1976
San Deigo, Calif (D)....	Pyrolysis	200	Liquid fuel/utility, Fe, Al, glass	1977

'RDF= refuse derived fuel WWC= waterfall combustion, RWI= refractory wall incinerator with waste heat boiler MCU = modular combustion unit RDF/WWC= Waterfall combustion using processed waste D= Pilot demonstration facility
SOURCE H Freeman of EPA(l)

operation at Blytheville, Ark,; Groveton, N. H.; and Siloam Springs, Ark. Industrial and institutional interest in these same small waste heat recovery incinerators appears to be strong and growing. A late-1976 survey identified 1 municipal, I school, 19 hospital, and 22 industrial incinerators not listed in table 29.(5)

Comparative Performance of Various Technologies

In order to gain some insight into how well these systems work, they are compared here in terms of four performance measures: (i) degree of proven commercialization, (ii) waste reduction efficiency, (iii) material recovery efficiency, and (iv) energy recovery efficiency. It should be noted at the outset that in many instances because of the emerging nature or proprietary status of these technologies, it is difficult to obtain adequate data for these comparisons.

DEGREE OF PROVEN COMMERCIALIZATION

EPA has assessed the "degree of proven commercialization" of each of the materials and energy recovery technologies.(6) Such classification is necessarily judgmental and is useful only as a general guide to commercialization status. Their classification scheme is augmented here with an additional category, "Research Technologies, " which includes processes that have not yet reached the pilot plant or demonstration stage, EPA's assessments have been reevaluated by 0TA and a few differences have emerged. The four categories are defined as follows:

- **Commercially Operational Technologies.**—Existing full-scale commercial plants that operate continuously. Consequently, there are some operating data available from communities and engineers already involved in the use of the process. Although such systems are being commercially utilized, they may be technically complex. To operate properly, they will require maximum use of available information leading to careful design and operation by knowledgeable professionals. There may be only limited operating experience with some parts of these plants. Thus, technological uncertainties may still exist.
- Developmental Technologies.—These are technologies that have been proven in pilot operations or in related but different applications (for example, using raw materials other than mixed MSW). There is sufficient experience to predict full-scale system performance, but such performance has not been confirmed. System design requires considerable engineering judgment about scale-up parameters and performance projections; consequently, the level of technical and economic uncertainty is generally greater than with commercially operational technologies.
- Experimental Technologies.—These include new technologies still being tested in laboratories and pilot plants. Because there is not sufficient information to predict technical or economic feasibility, such technologies should not be considered by cities contemplating immediate construction.
- Research Technologies.—These technologies, which are only in the laboratory testing stages with no pilot plant activity underway, are most technologically and commercially uncertain.

Tables 30 and 31 show OTA'S version of the EPA assessment of the degree of proven commercialization for energy and material recovery technologies. The only commercially proven technologies for energy recovery are waterwall combustion, modular incineration with heat recovery, and solid fuel RDF (wet and dry processes). Table 30 includes the waste-fired gas turbine concept. Considerable Federal research funds have been expended on this system which uses waste combustion gases to drive a gas turbine. It has not been included in this assessment because of serious corrosion and other problems.(6)

The only commercially proven material recovery technologies are humus production by comporting, magnetic recovery of ferrous metals, and low-grade fiber recovery by wet pulping. Other approaches have yet to be proven in an operational, economically sound project.

Aluminum recovery is classed as developmental because no plants are currently producing a steady stream of recovered alu-

Table 30.—Degree of Proven Commercialization of Energy Recovery Technologies

Commercially operational technologies
Waterwall combustion
Small-scale modular incineration with heat recovery
Solid fuel RDF (wet and dry processes)
Developmental technologies
Low Btu gas pyrolysis
Medium Btu gas pyrolysis
Liquid pyrolysis
Biological landfill conversion
Experimental technologies
Biological anaerobic digestion
Waste-fired gas turbine
Research technologies
Hydrolysis systems

SOURCE Office of Technology Assessment

Table 31.— Degree of Proven Commercialization of Materials Recovery Technologies

Commercially Operational Technologies
Comporting
Magnet ic recovery of ferrous metals
Fiber recovery by wet separation
Developmental technologies
Aluminum recovery
Glass recovery
Experiment/ technologies
Nonferrous recovery
Paper recovery by dry processes

SOURCE Off Ice of Technology Assessment

minum. The New Orleans facility recovered its first aluminum cans in March 1978. Samples were sent to Reynolds Metals Corporation for testing. Additional tests will be necessary before large quantities of aluminum can be recovered.(4) The Ames, Iowa, aluminum magnet was damaged in a winter freeze and only returned to operational status in mid-April 1978. The plant management had not yet (spring 1978) concluded the purchase agreement because the system had not been accepted from its manufacturer as operating satisfactorily. The Baltimore County facility aluminum magnet does not run on a continuous basis, but only when small amounts of RDF are being produced for an EPA contract calling for 3,000 tons for experimental cement kiln firing. Normally the shredded waste is used for landfill after the recovery of ferrous material, and aluminum is not recovered when the plant is running in this configuration. The Americology plant in Milwaukee, after correcting several problems, is in roughly the same situation as the New Orleans plant. Thus, none of these plants has yet demonstrated the sustained recovery of aluminum that is necessary before such recovery can be considered a commercially operational technology.

The status of glass recovery technology is similar to that of aluminum. It is, therefore, also considered to be in the developmental stage.

WASTE REDUCTION EFFICIENCIES

Reducing the amount of waste that must be landfilled is a major concern of municipal decisionmakers. Table 32 shows literature estimates of the residual fraction of MSW that must be disposed of by landfill or other means following resource recovery by the various technologies. As can be seen from this table, all of the systems reduce the landfill burden. Recovering both materials and energy helps reduce the disposal load. It is generally believed that residues that have been subjected to high temperatures in incineration or pyrolysis will be less hazardous in landfill because most pathogens cannot survive the high temperature and because incinerator residue should be less subject to subsidence. However, the products of combustion and pyrolysis must be examined to determine whether they create new kinds of toxic landfill effluents.

Table 32.—Estimated Waste Reduction Efficiencies of Resource Recovery Technologies

Technology	Residue as percent of input waste: Weight percent	Residue as percent of input waste: Volume percent	Reference
Waterwall combustion	25-30a	10	(6)
	20-35a	5-15	(7)
	25-30a	—	(8)
Small-scale incineration . . .	30a	10	(9)
Dry fluff RDF.	l0-15b	—	(8)
	20C	—	(Io)
Low Btu pyrolysis	15-20a	3-5	(Io)
Medium Btu pyrolysis	17C	2	(Io)
Liquid pyrolysis	27b	—	(Io)
	7b, d	1-2	(11)
Anaerobic digestion	17b	—	(11)

[a]with metals not recovered
[b]with metal recovery
[c]With ferrous recovery
dAssumes the char would have economic value and would not be landfilled

MATERIAL RECOVERY EFFICIENCIES

Table 33 shows the materials recovery efficiencies of various processes based on data from the literature. The National Center for Resource Recovery [NCRR) reports efficiencies of up to 99 percent when the aluminum magnet is run at extremely slow (not commercially feasible) speeds. Product contamination is a problem with aluminum recovery. To reduce contamination an “air knife” can be installed following the aluminum separator. As mentioned earlier, the quality of paper fiber and glass recovered by the technologies listed in table 33 is low. Ferrous recovery is the most commercially feasible of all the systems reviewed here. [Additional attention is given to the quality of recovered materials in chapter 3.] Other dry paper recovery processes such as the Flakt process are being explored in Europe where wood stock for paper is not as abundant as in the United States.

Table 33.—Materials Recovery Efficiencies

Technology	Percent of the waste stream content of each material recovered	Reference
Ferrous-magnetic	90-97	(6)
Paper fiber—dry[a]	23	(6)
Paper fiber—wet	50	(12)
Aluminum magnet[b]	65	(15)
Glass-froth flotation	65-70	(11)
Glass-optical sorting	50	(12)

[a]CECCHINI Process in Italy
[b]shredded cans at a 1 ton per hour feedstock rate

ENERGY RECOVERY EFFICIENCIES

There is currently no standard accepted way to evaluate the energy recovery efficiency of resource recovery systems. This problem is illustrated by one study that cites seven different efficiency figures from the literature, ranging from 29 to 49 percent, for the Occidental liquid pyrolysis process. Different efficiencies result from alternative ways of treating energy used by the process itself, from the choice of system boundaries for which the calculation is made, from the choice of higher or lower heating value of the waste, and from including or excluding the energy content of nonfuel materials. As the situation presently stands, it is possible to produce energy recovery efficiency figures to either enhance or detract from the apparent attractiveness of a particular system. The American Society for Testing and Materials (ASTM) Committee E-38 on Resource Recovery is examining energy efficiency calculations, but because of more pressing matters it has a low priority according to the committee chairman.(17)

Table 34 shows system energy efficiencies in terms of the energy content of the fuel produced, and in terms of the output energy available as steam. While comparison on the basis of available steam makes thermodynamic sense in terms of standard system boundaries, it ignores such important economic characteristics of the various waste-derived fuels as the quality of the fuel product and its transportability. The temperature of the steam produced by various technologies may differ considerably.

Table 34.—Energy Recovery Efficiencies of Resource Recovery Processes

Process	Efficiency basis: Energy in fuel produced[a]	Efficiency basis: Energy available as steam[b]
Fluff RDF	70[c]	49C
Dust RDF	80	63
Wet RDF	76	48
Waterwall combustion furnace	—	59
Modular incinerators	—	25-50
Purox gasifier	64	58
Monsanto gasifier	78	42
Torrax gasifier	84c	58[c]
Occidental Petroleum Co. pyrolysis	**26**	**23**
Biological gasification	**33c**	**29c**

[a] Higher heating value of the fuel product, less the heating value of the energy used to operate the system expressed as a percent of the heating value of the input solid waste It was assumed that electricity IS produced onsite using the system's fuel product
[b]in orde,t. compare all the processes on an equivalent thermodynamic basis, the energy available as steam was calculated using an appropriate boiler efficiency for each fuel product
corrected figures are based on communications with EPA and an EPA contractor (18,23).
[c]includes energy recovered from sewage sludge which also goes into the digester. This calculation also assumes that the filter cake residue from the digester IS burned to recover heat
SOURCE EPA Fourth Report to Congress, p 59, with corrections by OTA as noted All calculations are based on higher heating value of Input solid waste of 5,000 Btu per pound, with some i-n. organic materials removed

The basis for table 34 is a similar table in EPA's Fourth Report to Congress. However, several typographical errors in EPA's report have been corrected. In addition, data for small-scale incinerators have been added based on conversations with an EPA contractor, The energy savings from materials recovery have not been included. EPA's use of the term "net energy" in their version of table 34 differs from best practice in such calculations because of arbitrary limits on the system boundary.

The energy efficiency figures in table 34 are not based on tests from actual working systems. Rather, they were calculated from data available in the literature and from contacts with vendors. Therefore, care should be exercised in drawing inferences from this table, particularly where efficiency differences are relatively small.

Potential Energy Savings From Centralized Resource Recovery

Resource recovery can save energy in two ways: by substituting fuels or heat recovered from waste for nonrenewable energy sources: and by substituting recovered materials for their counterpart virgin materials.

Less energy is required to produce most industrial materials from scrap than from virgin sources. Therefore, recovering materials from MSW for recycling represents an energy savings. Using data from the literature(19,20,21 ,22) the potential energy savings were calculated assuming that in 1975 all the iron and steel, aluminum, copper, and glass were recovered from the MSW stream. The results of this calculation are summarized in table 35. Complete recovery of these materials would have saved 0.3 x 10^{15} Btu or 0.3 Quad. * This is equivalent to about 0,4 percent of the Nation's energy use in 1975.

To calculate the amount of nonrenewable energy that could be saved by recovery of fuel or energy from MSW it was assumed: (i) that 100 percent of the combustible waste (including paper) could either be recovered as fuel or burned, (ii) that the substitution would be on a Btu for Btu basis, and (iii) that raw MSW has an energy content as fuel of 5,000 Btu per pound. Thus, for the base year selected, 1975, the energy content of the 136.1 million tons of MSW generated would have been 1.36 x 10^{15} Btu or 1.36 Quads. This is equivalent to about 1.9 percent of the Nation's energy use in that year.

Thus, the maximum energy that could have been saved by centralized recovery of both energy and materials in 1975 is 1.66 x 10^{15} Btu or 2,3 percent of the energy used by the Nation in that year. In actual practice, however, the maximum amount of energy saved would be considerably less than calculated in these estimates. Technical, economic, and institutional barriers would act to limit the contribution of resources recoverable from MSW to the Nation's energy pool,

*One Quad = 10^{15} Btu = 1.055 exajoule.

Table 35.—Potential Annual Energy Savings From Recovery and Recycling of 100 Percent of Various Materials From MSW

Material	Energy savings (10^{15} Btu/year)
Iron and steel	0.08
Aluminum	0.19
Copper	0.01
Glass	0.02
Total	0.30

SOURCE Office of Technology Assessment

Resource Recovery Experience in Western Europe

Resource recovery, especially for energy production, is more widespread in Western Europe than in the United States. A recent study for DOE of 14 countries identified 181 plants containing 243 separate units. The 181 plants include a total of 413 furnaces.** Most of these units recover steam in waterwall or fire-tube boilers. Typical applications are electricity generation, steam for district heating and industrial use, and sewage sludge drying. Several plants preshred the refuse and recover ferrous metals before burning, and many have pollution control devices. Tables 36 and 37 show the geographic distribution of units, both furnaces and plants. (Furnace sizes are given in metric tons, which are equivalent to 2,205 pounds. The U.S. short ton is 2,000 pounds.)

In comparison with Western Europe, EPA identified seven waterwall combustion plants and three small-scale modular combustion units for MSW completed and operational in the United States in 1976. Not all of these seven large waterwall systems were able to market their steam. Thus, in terms of numbers of units, Western Europe is considerably ahead of the United States.

Individual furnaces in Europe are smaller than the large-sized units being installed in the United States. Thirty-four percent of the European furnaces are smaller than 5 metric

**EPA is currently examining European systems in a detailed study.

Table 36.— Waste-to-Energy Systems in Western Europe

Country	Number of unitsa	Number of plants[b]
Austria	2	2
Belgium	3	3
Denmark	45	31
Finland	2	2
France	29	20
Italy	16	14
Luxembourg	1	1
Netherlands	7	6
Norway	13	8
Spain	3	2
Sweden	22	16
Switzerland	33	29
United Kingdom	9	9
WestGermany	58	38
Total	243	181

aAUnit os a facility built at one time in a single locaton
bA plant is building which one or more waste-to-engery units is installed
SOURCE (24)

tons per hour, and 60 percent are smaller than 10 metric per hour. In contrast, for example, the Resco plant at Saugus, Mass., uses two waterwall combustion furnaces, each rated at682 metric tpd or 28 metrictons per hour. The only units larger than these operating in Western Europe are two 50-metric-ton per hour furnaces in the Paris, France IVRYII plant and a few 40-metric-ton per hour furnaces installed in West Germany.*

With the exception of the large furnaces in France and West Germany, other European plants use a modular approach to achieve large plant capacity. The French plant at Lyon Zeme achieves a daily capacityof 960 metric tons with four, l0-ton per hour furnaces. The Sorain Cecchini plant in Rome, Italy reaches 576 metric tpd with six, 4-ton perhourunits.

Most of the incineration units in Europe are in large cities that often have more than one facility. However, several small towns in Denmark have small units with capacities less than 5 metric tons per hour. Almost all these plants are used for hot water and district heating. In Switzerland, centrally located facilities serve rural areas. The plant at Monthey, for example, generates electricity from the solid waste of 57 villages.

There are institutional differences between European and U.S. society that affect resource recovery systems. Denmark has a law requiring source separation that removes a large portion of the organic combustibles from MSW and thus discourages certain kinds of centralized waste-to-energy systems. Comporting is successful in the Netherlands, whereas it usually fails in the United States. The Netherlands subsidizes comporting operations. Markets for the composted product, humus, are good in the flower and bulb industries.

Some of the factors that might explain European adoption of energy recovery incinerators are: (i) relatively high population densities with less land available for dumping, (ii) high fossil-fuel prices, (iii) cold climates in which district heating systems have long flourished, (iv) strong manufacturing firms including several furnace grate manufacturers, and (v) localized electricity production, which makes the sale of electricity easier (except in France and Italy, which have state monopolies) .(24)

Environmental and Workplace Health and Safety

This section examines the environmental and workplace health and safety aspects of resource recovery systems in order to determine whether problems exist that might require attention by Congress, the regulatory agencies, or the R&D community. The topics addressed include air, liquid, and solid emissions from resource recovery facilities, and workplace conditions such as noise, pathogens, dust, toxic substances, explosion and fire hazards, and the safety of mechanical and electrical equipment. Few, if any, of the problems discussed appear to be insoluble,

*One DOE official believes that the French will not again build and try to operate systems with large furnace units but would achieve large scale by using a modular approach with several smaller furnace units,(25)

Table 37.—Distribution of Waste-to-Energy Furnaces, by Capacity and Country in Western Europe

Country	Furnace size (metric tons/hour)[a]						
	0-5	5-10	10-15	15-20	20-25	Over 25	Total
Austria	—	3	—	2	—	—	5
Belgium	1	5	—	—	—	—	6
Denmark	35	10	7	1	—	—	53
Finland	—	4	—	—	—	—	4
France	13	26	10	4	—	2	55
Italy	18	10	9	—	—	—	37
Luxembourg	—	—	2	—	—	—	2
Netherlands	—	5	8	4	6	—	23
Norway	12	1	—	—	—	—	13
Spain	—	1	3	—	—	—	4
Sweden	20	8	3	4	—	—	35
Switzerland	31	9	10	3	—	—	53
United Kingdom	2	5	12	—	—	—	19
West Germany	9	20	37	20	13	5	104
Total	141	107	101	38	19	7	413[b]

[a]To convert metric tons to short tons, multiply by 1.1.
[b]Many units have more than one furnace.
SOURCE: (24).

but they could add to the cost of building and operating resource recovery plants and constrain the range of practical technologies.

Environmental Factors

Questions have been raised about potential air and water pollution from resource recovery plants. Emission standards exist for such air emissions as particulate matter, sulfur dioxide, nitrous oxides, carbon monoxide, and hydrocarbons. Because MSW contains larger concentrations of some heavy metals and other hazardous substances than coal and oil, there is increasing interest in assessing the potential health and environmental hazards of these substances. However, very little good data are available for this purpose. A report by the Midwest Research Institute (MRI) for EPA lists 84 substances known to be in MSW; many of which are known to be hazardous. Research is cited which indicates that a number of hazardous inorganic substances are found in higher concentrations in RDF than in coal.

EPA has recently initiated research to build a data base on the environmental aspects of resource recovery systems. This should enable development of control technology, if necessary. The consequences of hazardous substances in resource recovery systems are currently not understood and there are no regulatory standards applicable to their emission into the air or water, or as solid waste. EPA has proposed an ambient air quality standard for lead and is considering regulation of other hazardous materials.

AIR EMISSIONS

Some data exist on emissions of the five "criteria pollutants" (particulate, sulfur oxides, nitrogen dioxide, carbon monoxide, and photochemical oxidants) from incineration and from combined RDF/coal-fired systems. Little data on the emission of these pollutants from pyrolysis or biological systems are available. Air emissions from pyrolysis plants can contain particulate matter as well as hydrocarbons and such gases as hydrogen chloride, hydrogen sulfide, and nitrous oxides. Air pollution from biological systems can result from the incineration of digester filter cake residues. Other air emissions can result from cleaning methane digester gas. The characteristics of these potential pollutants are unknown.

Air pollution control equipment is necessary for incineration systems. * Average uncontrolled particulate emissions from a modern waterwall incinerator were found to be 1.24 grains per standard cubic foot (SCF) (2.84 grams per standard cubic meter, g per SCM) compared to the EPA standard of 0.08 grains per SCF (O. 18 g per SCM).(7) However, air pollution control technology, when properly selected, installed, and operated appears to bring particulate emissions within EPA standards.(7) Since waste has a higher ash content than fossil fuels, burning RDF with coal may increase the load on air pollution control equipment. The efficiency of electrostatic precipitators may be reduced when MSW is burned with coal at high boiler utilization rates.(10)

Research indicates that sulfur dioxide, oxides of nitrogen, carbon monoxide, and hydrocarbons are not likely to cause problems when MSW is burned. Since MSW has a much lower sulfur content than most coals, cofiring RDF and coal could reduce sulfur dioxide emissions per unit of electric energy produced. In cofiring RDF and coal, for which there are more data than for waterwall incineration, there is evidence of increased air emissions of such heavy metals as beryllium, copper, lead, cadmium, and mercury. Based on very limited tests, researchers at Iowa State University reported increases in copper and lead air emissions from the powerplant at Ames when RDF was added to the coal. * *

*Incinerators of less than so tpd are excluded from Federal air quality standards.(28) There is great variability among States and between State and Federal standards for incinerators. For example, in the Baltimore and Washington metropolitan areas of Maryland, single-stage incinerators with a capacity of less than 5 tons per hour are prohibited. (29l) It is not clear whether this ban would apply to small, two-stage incinerators of the kind under discussion here.

**A furor was caused in the fall of 1977 when researchers erroneously reported very high concentrations of toxic substances in the RDF from the Ames, Iowa RDF plant. The error was subsequently corrected.

Hydrogen chloride gas produced by burning plastics in MSW can combine with water to form hydrochloric acid and may create potential health and corrosion problems. Hydrochloric acid, if it is found to be a significant health problem, should not be difficult to control with scrubber technology.

Little is known about air pollution from cofiring liquid pyrolysis fuel with oil, since the Occidental pyrolysis plant in California is not in operation.

Dry process refuse-derived-fuel plants may emit dust, odor, and noise to the plant environment, but these can be confined to the plantsite with proper design. (See the following section for a discussion of these substances in the workplace environment.)

LIQUID EMISSIONS

Important characteristics of waste water from resource recovery systems, some of which could require control, are: high temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), hydrogen ion concentration (pH), alkalinity, hardness, total solids, total dissolved solids, suspended solids, settleable solids, phosphates, nitrates, chlorides, fluorides, heavy metals, odor, and color.(8)

Not much is known about the characteristics of water pollutants from incineration processes, in which one potential source of waste water is from ash slurrying. Studies at the St. Louis RDF/coal-fired plant indicate increased levels of BOD, COD, and total dissolved solids. Characteristics of waste water from pyrolysis plants are not well known, but it may be high in BOD, COD, alcohols, phenols, and other organic compounds. Biological systems present waste water pollution problems because the process requires large quantities of water in the digesters, part of which is recycled, but part of which must be discharged. Little information is available on these emissions since the demonstration plant at Pompano Beach is still under construction.

SOLID RESIDUALS

Solid wastes from resource recovery plants include combustion ash, pyrolysis residues, and particulate matter recovered by air pollution control devices, all of which can produce undesirable leachates when used as landfill. Although data are scarce, fly ash particulate from waste incineration may contain trace elements such as cadmium, lead, beryllium, and mercury (30)) The solid sludge from biological processes may contain bacteria that could create leachate problems if landfill is chosen for its disposal.

Occupational Health and Safety Factors

Persons working in and around resource recovery plants may be subjected to potential health and safety hazards such as bacteriological and virological pathogens, dust, toxic substances, noise, explosions and fires, and mechanical and electrical equipment. Since these systems are new, little is known about the characteristics of the hazards they pose, This section describes these hazards and reviews some of the ongoing research and regulatory activity associated with them.

NOISE

Resource recovery processes such as shredders, air classifiers, trommels, and cyclones can produce noise in excess of present Occupational Safety and Health Administration (OSHA) standards. A study of a small, 3-ton per hour resource recovery system reported noise levels in excess of 90 dBA* near these devices. Control of noise in such equipment by engineering design will probably be costly. Consequently, administrative controls (limiting the time exposure of employees in high noise areas) and personal protective equipment may be needed to control exposure. Noise levels in larger commercialized shredders will undoubtedly exacerbate the problem. Current OSHA regulatory activity should be adequate to control noise exposure unless the plant is operated by a municipality in a State in which municipal employees are not covered by OSHA.

PATHOGENS

As MSW is shredded, air-classified, and transported within resource recovery facilities, workers are exposed to bacterial, fungal, and virological pathogens contained in the waste stream. Air sampling indicates that total bacterial counts in the Ames plant are around 100 times greater than in normal nonplant environments.(34) MSW contains human and animal fecal matter due, for example, to the use of disposable diapers and the disposal of animal litter. Fecal coliforms and fecal staphylococci at the Ames facility are about 5 percent of total bacteria. Good data on the impact of these pathogens on the health of workers are not available. No standards exist for microbiological contaminants in the workplace except for hospital operating rooms—a standard not applicable to resource recovery plants.

The data base for viral contaminants in resource recovery plants is even less adequate. Even though viruses would be expected in such plants, air sampling studies done by MRI for EPA have not detected any. The sampling method may be inadequate, and further tests are underway at Ames .(34)

Epidemiological studies of persons with long-term exposures to environments typical of resource recovery plants do not exist. One study of New York City uniformed sanitationmen found no evidence of an increased amount of chronic pulmonary disease when compared to other job titles in the department.(35) The same author reported that these sanitationmen have a rate of coronary heart disease almost twice that of other groups of males in similar age categories. He is unable to explain this finding, and urges that epidemiological studies are needed to identify causes.

Some research is underway on pathogens in resource recovery plants. EPA is funding a

*Ninety decibels on the A scale (90 dBA) is the maximum noise level permitted for an 8-hour day by present OSHA standards. This level is thought to be too high by some organizations who prefer an 85 dBA standard.

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study in this area by MRI. The National Institute of Occupational Safety and Health (NIOSH) is presently funding research at the Stanford Research Institute on occupational health and safety (emphasis on health) in emerging energy industries. One of the tasks being carried out is an assessment of health and safety problems in resource recovery facilities. This limited preliminary study is expected to produce a qualitative assessment of potential problems with pathogens and to suggest what needs to be done. Related work is being done at the Ames Laboratories of DOE. ASTM has formed a subcommittee on health and safety of its Committee E-38 on Resource Recovery. One of this subcommittee's tasks is to develop standardized methods for sampling microbiological aerosols. Some researchers in this field indicate that if information on bacteriological and virological experiments done by the military could be declassified, research on resource recovery plants might be expedited.

DUSTS AND TOXIC SUBSTANCES

Processing MSW produces considerable dust—another potential health hazard. OSHA standards for dust specify maximum permissible concentrations of dirt or nuisance dust. However, because of the variety of materials in MSW there is additional concern about specific substances such as asbestos, metal dusts, and other toxic substances. In one test at a resource recovery plant asbestos fibers were not found in the air, and a single test for aluminum and cadmium dust gave negative results. Roughly half the dust on a particle count basis at the Ames plant is composed of particles less than 4 microns in diameter. Similar results are reported elsewhere.(33) Retention of dust in the lungs is highest for particles of about 2 microns, so it appears that MSW dust retention may present a problem. The National Center for Resource Recovery reports that an average of dust samples in their experimental test facility showed only 12 percent of the dust to be in the respirable range.(37) Their dust measurements were made on a weight basis, rather than the particle count basis used at Ames. Dust particles too large to enter the lungs can be captured in mucous membranes and ultimately carried into the digestive tract. This is another source of infectious potential of unknown significance.

Obviously, dust control measures and personal protective equipment for workers in resource recovery plants need considerable attention on the part of workers, managers, and regulators. In the long term more work needs to be done to characterize the nature of dust in resource recovery plants and to assess the health effects of long-term exposure to this kind of dust.

EXPLOSIONS AND FIRES

MSW occasionally contains dynamite; gunpowder; flammable liquids and gases; aerosol cans; propane, butane, and gasoline fuel containers; and other explosive substances. When such substances are shredded an explosion can occur. A 1976 study of explosion hazards in refuse shredders reported 95 explosions in the 45 MSW-shredding plants included in the survey. Thirty-four of the shredding operations had experienced at least one explosion. Injuries were reported in only three incidents. No fatalities occurred. Only five of the explosions produced more than $25,000 property damage or put the shredder out of operation for more than 1 week. Because shredders are designed to withstand mild explosions, shredder explosions usually damage peripheral equipment such as ducts and conveyors.

Protection from shredder explosions can be achieved by manual or automated surveillance of input material, explosion venting, explosion suppression/extinguishing systems, water spray, or equipment isolation. Manual screening to remove explosive material is already being practiced, but cannot be expected to remove all explosive substances. The feasibility of automatic detection of such materials is questionable. Shredders can be designed with hinged walls and tops to allow rapid venting of exploding gases. This method can minimize shredder damage, but requires careful attention to the protection of personnel and adjacent equipment. Explosion extinguishing systems detect the pressure increase at the beginning of an explosion and trigger the release of chemical explosion-suppressing agents into the shredder. When operating properly these devices can control shredder explosions and extinguish flames. However, such devices cannot control explosions of self-oxidizing explosives such as ordnance. Continuous water sprays in the shredding operation can reduce explosion and fire hazard, but water in the shredded refuse reduces its heating value, reduces the efficiency of ferrous separation, and can cause shredder corrosion. Finally, personal injury from shredder explosions can be controlled by isolating the shredder and keeping employees away from it while in operation.

It appears possible to reduce the incidence of shredder explosions by substituting a rotary drum air classifier for the shredder as the first step in waste processing. Using this approach, only the light fraction of the waste is shredded while most of the potentially explosive components become part of the heavy fraction, which is not shredded. Such a system has been tested at the waste shredding facility in New Castle, Del.

Dust from MSW shredding does not appear to be a great explosion hazard. However, mixtures of combustible dust and flammable gas or vapor may explode even though neither the dust nor the gas by itself is in an explosive concentration range. In addition, dust can be a contributing factor in fires caused by explosions.

Dust explosions may be more likely where fine powder RDF is produced. An explosion with a fatality occurred at the ECOFUEL II" plant in East Bridgewater, Mass., in the fall of 1977. According to the plant owners, Combustion Equipment Associates (CEA), the cause of this explosion is still undetermined. (39) CEA claims that their powdered RDF is less explosive than grain or starch dust or pulverized coal.

MECHANICAL AND ELECTRICAL HAZARDS

Resource recovery systems contain an array of mechanical and electrical devices ranging from equipment for handling materials (front-end loaders, cranes, and conveyors) to the separation and combustion processes discussed earlier. This environment exposes employees to a variety of potential accidents. However, most of these devices fall under existing OSHA safety regulations. Assuming that these regulations are enforced and that workers are covered, control of these hazards maybe adequate.

Conclusions

Several potential environmental and occupational health and safety problem areas in resource recovery need further investigation. Many questions about the environmental impacts of waste-to-energy systems remain unanswered. EPA is now monitoring and studying control of pollution from resource recovery facilities as they come online. If construction of resource recovery facilities continues, this activity may need to be accelerated to ensure against the emergence of environmental problems in the future. Exploration of control technologies for heavy metals in air emissions and for toxic leachates from solid residuals of resource recovery in landfill, is particularly important.

Some of the occupational health and safety problems such as noise and mechanical and electrical hazards can probably be controlled by OSHA'S existing regulatory apparatus. However, work on pathogens as health hazards should be accelerated. NIOSH has recently announced an interest in developing a criteria document on occupational safety and health standards for incineration systems. Under this procedure, 1982 is the earliest date for promulgation of a health and safety standard for incinerators. NIOSH should consider issuing a criteria document for all the resource recovery technologies, not just incineration, on an accelerated time schedule. Finally, relevant military research on pathogenic agents should be made available.

Plant Size and System Design: The Question of Scale

Overview

Most of the resource recovery technologies in the United States examined in this chapter are currently being designed and built as large-scale plants, with capacities in the 1,000- to 3,000-tpd range. The exceptions are small-scale modular incinerators and biological conversion processes. Such large plants are attractive because they promise significant economies of scale in processing (average costs decline as plant size grows—see chapter 6) and because they can include economical systems for the recovery of materials as well as energy.

Recently, however, strong interest has emerged in small-scale, modular incinerators with heat recovery. This interest is stimulated by the realization that the institutional, financial, and technological barriers to large-scale systems discussed in chapters 6 and 7 are real, especially in view of the uncertainty about the capability and reliability of available technologies.

Interest in small-scale systems has also paralleled the attention being given to the concepts of "decentralized," "appropriate," or "soft" technology. These concepts are being examined for many technologies such as energy supply, sewage treatment, and provision of government services. For resource recovery systems these concepts suggest that the scale of a technology should match the scale of its users.

In the remainder of this section, the implications of scale matching are explored for resource recovery system design. The sizes of potential producers and consumers of recovered energy are examined, and some of the advantages and disadvantages of small- and large-scale systems are addressed.

Matching producers With Consumers

ENERGY CUSTOMERS

Resource recovery plants can be viewed as factories that produce energy from a raw material—MSW. The larger such a plant, the more waste it can process from more people, and the larger the energy customer it requires. For example, a plant with 1,000-tpd average capacity can process the waste of approximately 570,000 people. The energy content of that waste as fuel is about 9 billion Btu per day, or the equivalent of the energy required to support a 37-megawatt electric (MWe) powerplant. * Such a powerplant would, in turn, serve about 3 percent of the electric power needs of the 570,000 people; who would use a total of about 1,200 MWe.

Electric powerplants are often considerably larger than 37 MWe; in fact, plants of 1,000 MWe are not unusual. Because electric powerplants are large consumers of fuel, they have been suggested as major potential customers for the fuel or energy output of resource recovery projects. However, to date utilities have been reluctant to use fuel from these sources, in part for the financial and institutional reasons discussed in chapter 7. In addition, however, utilities may be less than enthusiastic because solid waste as a fuel source is just too small. The potential financial, regulatory, technical, and political problems of burning solid waste may not be worth the effort for only 3 percent of a utility's fuel needs.

On the other hand, the energy output from a 1,000-tpd" plant is much too large for most alternative customers for energy as steam or hot water. For example, the space heating and cooling energy demand of office buildings is estimated to be on the order of 850 Btu per ft^2 per day.(42) Thus, a 1,000-tpd plant might

*This calculation is based on an MSW heating value of 9 million Btu per ton, a per capita waste generation rate of 3.5 pounds per day, and an electrical generation efficiency of one-third.

serve up to 5 million ft^2, * an area corresponding to a very large office building or multi-building complex, such as the Pentagon, which has 6.55 million ft^2 of space. (43) One alternative is for a large, centrally located facility to serve a number of surrounding customers, This approach has been taken in Nashville, Term., and in a plant under construction in Akron, Ohio.

Another alternative is to build a number of small resource recovery plants that produce steam or hot water. These modular combustion units (MCUS) would serve such customers as small- to medium-sized manufacturing plants and office buildings, and large institutions. The number of such potential customers greatly exceeds the number of potential industrial customers for the output of the larger 1,000- to 3,000-tpd plants.

The large number of potential industrial, institutional, and commercial users of heat from MCUS is suggested by the following information from DOEO(44) Several institutions are already using MCUS to recover energy from their own wastes, and in 1972, about 25,000 small boilers comparable in size to MCUS were producing heat for industrial processes. This indicates considerable potential industrial interest in MCU heat, especially as energy costs rise. There are also some 7,200 hospitals, 3,026 public and private colleges and universities, and 108,676 public and private elementary and secondary schools, Although many of these institutions are too small to use the entire output of even a small MCU, only 2 percent of them would be 2,400 potential users. For commercial buildings, Friedricks(43) thinks there might be a "realistic potential" for 1,000 to 2,000 MCUS. The possibility of matching the output of small-scale modular incinerators for MSW to the many potential users of heat warrants more extensive examination.

WASTE PRODUCERS

Experience to date suggests that in the United States resource recovery plants can be implemented more easily to serve a single community, or part of a community, than to serve a multicommunity region. As noted in chapter 7, the institutional, political, and economic barriers to multicommunity projects are difficult to overcome.

The potential market for resource recovery plants of various sizes can be estimated by considering the size distribution either of individual communities or of Standard Metropolitan Statistical Areas (SMSAS). A bigger market is predicted for small plants when the first approach is used and for large plants using the second approach.

Table 38 shows the size distribution of American cities along with estimated waste generation rates, neglecting any change in per capita waste generation with a change in city size. Only 23 cities are large enough to support a 1,000 + tpd plant on their own. Another 34 cities fall in the 500- to 1,000-tpd range. On the other hand, over 800 cities might use resource recovery plants in the 50- to 500-tpd range, and an additional 1,200 cities are in the 15- to 50-tpd group. These numbers suggest that there may be a large potential market for "small" resource recovery plants.

A somewhat different view of the potential for large plants is suggested by table 39, which shows the distribution of U.S. population in the SMSAS. These areas typically in-

*Assumes roduction of 4 million Btu of steam or hot water energy per ton of MSW.

Table 38.—U.S. City Size, Population, and Waste Production in 1975

City size range (thousands)	Number of cities[a]	Population[a] (million)	Average population per city (thousands)	Average municipal solid waste per city (tons/day)[b]
5-10 . . . .: . ;	‘1,463	10.3	7.1	12
10-20 .., ...	977	13.8	14.1	25
20-25	238	5.3	22.0	39
25-50	514	17.9	34.9	61
50-100	230	16.1	70.0	122
100-250	105	14.9	142,0	248
250-500	34	11.8	348.0	609
500-1,000	17	11.3	664.0	1,160
over 1,000. . . .	6	17.8	2,970.0	5,200

[a] SOURCE (45)
bEstimated by OTA based on 3.5 pounds, of MSW per capita Per day

Table 39.—U.S. Standard Metropolitan Statistical Areas (SMSAS) Size, Population, and Waste Production in 1975

SMSA size (thousands)	Number of SMSAS'	Population[a] (m!llion)	Average population per SMSA (thousands)	Average municipal solid waste per SMSAb (tons/rjay)
un-der-l OO .-. .	27	2.5	92	160
100-250	97	16.6	171	300
250-500	63	22.7	361	630
500-1,000. . . .	37	27.1	733	1,280
1,000 -2,000..	20	28.3	1,417	2,480
2,000-3,000. .	8	19.0	2,373	4,150
over 3,000 . . .	7	40.0	5,693	9,960

aSORCE (46).
bEstimated by OTA based on 3.5 pounds of MSW per capita Per day

elude several cities and contiguous unincorporated areas. Table 39 shows that seven SMSAS produce around 10,000 tpd of MSW, 28 more are in the 3,000-tpd range, and another 37 are in the 1,200-tpd" range.

Advantages and Disadvantages of Small and Large Plants

Large resource recovery plants can achieve significant economies of scale and can include economical systems for recovery of both materials and energy. They represent large financial investments and may thus serve as a dramatic focus for the attention of citizens, industry, and government officials.

The disadvantages of large plants include: (i) their high first cost; (ii) the inflexibility they create by their requirements for future utilization in order to meet debt obligations, (iii) the difficulty of identifying a suitable energy customer; (iv) the problems of regionalization; (v) their vulnerability to strikes, sabotage, and mechanical failure; and (vi) the logistics and cost of delivering such large amounts of waste to a single site.

The advantages of small-scale systems include: (i) the fact that a large community or region can start small and add units or facilities incrementally; (ii) their compatibility with smaller waste producers and energy consumers; (iii) the system reliability inherent in operating several dispersed units; (iv) the fact that they can help avoid the political problems of regionalization; (v) their potential for reducing siting problems by locating them on customer property; and (vi) the fact that they can be produced in relatively large numbers with factory technology according to standard plans and installed relatively quickly with greater use of local skills.

The disadvantages of small-scale systems include: (i) potentially higher direct costs per unit of waste processed, (ii) the need to control a large number of relatively small air pollution sources, (iii) the requirements of small waste incinerators for auxiliary oil or gas fuel, and (iv) the fact that materials recovery in small-scale systems may be uneconomic since shredding and classifying would be very expensive at small scale. However, little or no thought has been given to small-scale materials recovery systems, or for that matter to small-scale cogeneration of electric power from MSW.

In comparing the advantages and disadvantages of small and large resource recovery plants, two characteristics warrant further elaboration: reliability and redundancy considerations, and implications for technological innovation.

The consequences of system failure are potentially more serious with one large plant than with several small plants. This fact creates the need in large plants to build in costly storage space, backup landfill, or equipment redundancy. To illustrate, consider two alternative ways of providing for resource recovery in a given city: one 1,000-tpd facility without storage or landfill, or five dispersed 200-tpd plants. If the waste that goes to any one of the 200-tpd plants could be temporarily redistributed to the others in the event of failure in any one plant, then the system of five plants possesses a kind of built-in redundancy. It can be shown with reliability theory that the reliability [probability of successful operation) of a single 1,000-tpd plant would have to be 0.9997' to equal the reliability of the five plant system if the reliability of the individual 200-tpd" plants were only 0.80.

Factory production of a larger number of smaller incinerators may also have implications for incremental technological innovation and for system performance standards, both of which relate to aspects of potential Federal involvement. With several producers of small systems competing for sales to numerous municipalities and other buyers, market forces might stimulate technological improvements with minimal Federal involvement. In the case of construction of a smaller number of large, custom-designed systems, however, which take a relatively long time to plan and construct, market forces may not be adequate to induce technological innovation, and there may thus be greater pressure for Federal assistance. But the presence of a large number of competing systems may tend to complicate the technology/vendor selection process for local officials. Under these conditions, Federal technical assistance to local governments might be as important as if larger systems were involved.

Research and Development in Resource Recovery: The Federal Role

Background

The Federal Government has sponsored research, development, and demonstration programs in resource recovery for the last 15 years; first in the Public Health Service and later in EPA, in the Energy Research and Development Administration (ERDA) (now DOE), in the National Bureau of Standards, in the Bureau of Mines, and in the National Science Foundation. A good part of the funds has been spent on several large-scale demonstration plants. Other work has been done on innovative separation technologies, environmental impacts of resource recovery, and characterization of recovered resources. The Federal Government has also funded a variety of economic evaluations and state-of-the-art review studies.

Federally funded demonstrations have limited usefulness as a means for promoting the diffusion of technology. A recent study by OTA on the role of demonstrations in Federal R&D policy(47) found that only a low rate of success can be expected. Furthermore, the evaluation of the success or failure of a demonstration will be difficult and subjective. In part, this is because there is frequent confusion over the goals of a demonstration project, and in part because the information received from a project is likely to be unclear and imperfect.

In the last decade there have been several vigorous private sector R&D programs, demonstrations, and commercial ventures, sometimes jointly with Federal agencies. A privately funded R&D center has been in operation at the National Center for Resource Recovery, which has also received Federal grant and contract funds.

The following discussion of Federal R&D needs for resource recovery is set within this context of vigorous private sector activity and an important but limited Federal role in technology demonstration.

R&D Needs

The technical problems that have occurred at many of the operational or demonstration plants are sufficient evidence that more R&D is needed to make the technologies work reliably and economically. Much of this work might be accomplished most effectively by private firms in the normal process of commercial development. In view of the considerable existing private activity, the need for a Federal role to further support pilot plant and large-scale demonstration activity is limited.

However, Federal R&D programs concerned with potential environmental and occupational problems of resource recovery are needed because the private sector usually underinvests in such research, and because it is unlikely to be done by State and local governments or labor organizations. Such research should be focused on identifying and clarifying hazards to health, and on developing methods for their control. At the same time, a vigorous program to enforce health, safety, and environmental standards would help to stimulate this kind of R&D in the private sector. A Federal R&D program for occupational and environmental problems is also needed in order to develop and maintain a reservoir of knowledgeable government personnel who can participate in the regulatory process.

R&D needs and problem areas in resource recovery technology have been presented in the literature. (10,48) The list in table 40 illustrates their range. It is beyond the scope of this assessment either to develop a comprehensive list or to set priorities.

Many of the problems listed in table 40 could be dealt with best in the process of commercial development by private firms. However, there may be a tendency to neglect the more fundamental research questions, such as: (i) materials characterization; (ii) processes of size reduction, separation, combustion, and chemical reaction; and (iii) exploratory design work on innovative systems for purifying and utilizing recovered materials, and for utilizing energy products, particularly at small scale. Consequently, there may also be a useful Federal role in dealing with these problems.

Table 40.—Selected Research, Development, and Demonstration Needs for Resource Recovery Technologies

HanLing and storage of RDF; fluff, densified, anD powdered.
—Material handling processes to cope with the abrasive, corrosive, and mixed nature of MSW.
—Ferrous, aluminum, nonferrous (nonaluminum), and glass recovery improvement and optilmization.
—Shredder optimization.
—Air classifier optimization.
— Resource recovery with mixed wastes such as: MSW with sewage, commercial waste, industrial waste, agricultural waste, forestry waste, etc.
—Fundamental parameters in MSW pyrolysis processes.
— Fundamental combustion parameters in firing all classes of RDF and raw MSW with traditional fuels.
— Fundamental MSW bioconversion parameters.
—Fundamental hydrolysis processes for MSW.
—CofiMing of MSW with sewage sludge.
—Corrosion in the combustion of MSW.
—New uses for glass aggregate, pyrolysis char, etc.
—Upgrading of fiber recovered from MSW.
—Improved recovery of materials from incinerated waste.
—Use of magnetic fraction from MSW in foundries.
—Systems optimization problems such as cost effectiveness of trammeling prior to shredding, particle size interaction with grate and boiler design, etc.
—Resource recovery processes in synergy with other nonwaste developments such as biomass energy conversion, cogeneration, industrial hydrolysis, etc.
—Small-scale materials recovery processes.
—Small-scale cogenerat ion.
—Small-scale combustion processes.
— Markets for small-scale energy output.

SOURCE Office of Technology-Assessment

Findings on Technologies for Centralized Resource Recovery

Widespread interest in the systematic recovery of materials and energy from MSW in the United States is just a decade old. The construction of centralized facilities for separating MSW into useful components has only recently been considered as one potentially important approach to the problems of waste management. The rationale for centralized resource recovery has been threefold: (i) effective and safe disposal of solid waste, (ii) recovery of materials for recycling, and (iii) production of energy from the combustible portion of the waste. These are also the major components of the potential revenues from resource recovery.

A number of technologies for burning the combustible portion of MSW or for converting it to solid, liquid, or gaseous fuels are at various stages of development. Techniques have also been developed, with differing success, for recovery of ferrous metals, aluminum, glass, nonferrous metals, and paper fiber. Waterwall combustion and small-scale modular incineration to produce steam, and the production of refuse-derived fuel (RDF) by wet and dry processes are currently the only commercially operational methods for recovering energy. The only commercially operational technologies for recovering materials from mixed MSW are the magnetic recovery of ferrous metals, the recovery of low-grade fiber by wet separation, and the production of compost by natural processes. Aluminum and glass recovery are being actively explored as is energy recovery by both anaerobic digestion and pyrolysis.

Energy can be recovered by centralized resource recovery either as fuel or as heat, and also as the savings that accrue from recycling materials. As an upper limit, the total recovery of all energy in MSW could supply about 1.9 percent of the Nation's current annual energy consumption. Recycling all of the iron and steel, aluminum, copper, and glass could save about 0.4 percent more for a total savings of 2.3 percent of current energy use, or the equivalent of about 800,000 barrels of oil or 200,000 tons of coal per day, Thus, centralized resource recovery might play a small, but not insignificant role in conserving energy. Technical, economic, and institutional factors, however, will keep the energy saved by resource recovery in the foreseeable future to a fraction of its potential.

Relatively little is known about the effluents from operating centralized resource recovery plants or about the nature and degree of workplace hazards they may present. This is largely because there has been little opportunity to gather data and because there is considerable variability in and ignorance about the composition of both MSW and the recovered products. A number of studies currently underway should produce some information and data about air and water emissions, bacteria and viruses in the plant environment, and toxic substances in all media including solid residuals. Authority exists for regulating these workplace and environmental problems, if needed. Should activity in centralized resource recovery accelerate, it will be desirable to step up research and to promulgate regulations to control any potentially harmful side effects.

Over the past 15 years, there have been a number of federally funded research, development, and demonstration projects concerned with centralized resource recovery, There has also been vigorous activity in the private sector. The Federal R&D presence would be most effective in identifying, evaluating, and controlling environmental and occupational problems: in characterizing materials; in basic studies of processes for size reduction, materials separation, combustion, and chemical reaction: and in exploratory designing—particularly of small-scale systems for processing and using recovered materials and energy, The remaining technical problems would probably be best solved in the course of commercial development by private firms.

Recently, there has been a substantial shift from materials recovery to energy production as a more significant driving force. This shift, which has taken place because energy prices have risen more rapidly and steadily than scrap materials prices over the last several years, may have important implications for resource recovery system planning, design, and operation:

- It creates the need to consider more carefully matching resource recovery plants with the potential customers for the energy produced.
- Attention to such matching may induce a shift from large, centralized to small, dispersed resource recovery plants.
- With smaller plants there may be less need to consider regionalization of solid waste disposal, with its attendant problems,
- There may be increased attention to direct incineration and to cofiring of waste with coal, as opposed to more exotic approaches.
- There may be less recovery of materials from waste than had been envisioned earlier since materials recovery may be less feasible in small plants.
- There may be an increased urgency to assess, regulate, and control potential environmental and workplace problems.
- There may be less concern that beverage container deposit legislation might impair resource recovery development, if material revenues become relatively less important.

- There may be increased flexibility for designing resource recovery systems that include source separation activities, and that can respond more readily to changing patterns of waste generation in the future.

Only electric powerplants, large factories, or large complexes of office buildings can consume all the energy output of a 1,000-tpd resource recovery facility. These kinds of potential customers have proven to be difficult for proposed resource recovery projects to reach. Electric utilities have been less than enthusiastic because it presents technical difficulties and because they have essentially no incentive to use refuse-derived energy and, if they do, face many problems. In a given service area, MSW can provide only a few percent of the fuel needs of an electric utility. Thus, a' utility must contend with numerous difficulties to obtain just a minor part of its total fuel supply.

On the other hand, for smaller quantities of refuse-derived energy there are a large number of potential customers such as office buildings, institutions, and smaller factories. Smaller resource recovery plants, say in the 25- to 200-tpd range, might adequately serve their energy needs. These would help to avoid some of the problems that arise when several communities attempt to regionalize in order to build large plants. Smaller resource recovery plants, which are more common in Europe, may feature direct incineration to produce steam or hot water and may forego materials recovery altogether. They may also allow for a more flexible approach in a community or region by making it possible to adopt resource recovery gradually rather than all at once.

However, a few cautionary words about smaller energy recovery systems are in order. Not enough is known about their reliability, or about the environmental and workplace health implications of operating a network of dispersed, small plants. Also, more needs to be known about the energy demand characteristics of the small customers mentioned above, in order to learn whether they can indeed become consumers of energy from waste.

References

1. Freeman, H., "Pollutants from Waste-to-Energy Conversion Systems," *Environmental* Science and Technology, 12, 1252-1256, November 1978.
2. EPA, "Office of Solid Waste Management, Fourth Report to the Congress, " Resource Recovery and Waste Reduction, Publication SW-600, Aug. 1, 1977.
3. *Solid* Waste Report, Oct. 9, 1978, pp. 165-166.
4. *NCRR* Update, March 1978, vol. VII, no. 3.
5. Ross Hofmann Associates "Summary of Controlled Air Incinerator Waste Heat Recovery Systems, " Coral Gables, Fla., 1976. Made available to OTA by DOE.
6. EPA, "Resource Recovery Plant Implementation: Guides for Municipal Officials: Technologies, " Report no. SW-157.2, 1977.
7. Weinstein, N., and R. Toro, Thermal Processing *of* Municipal *Solid* Waste *for* Resource and Energy Recovery, Ann Arbor Science Publishers, Ann Arbor, Mich., 1976.
8. Pavoni, J. L., J. E. Heer, and D. J. Hagerty, Handbook *of Solid* Waste Disposal, Van Nostrand, 1977.
9. "Evaluation of Small Modular Incinerators in Municipal Plants," EPA Report SW-113c, by Ross Hofmann Associates, Coral Gables, Fla., 1976.
10. Wilson, E. M., J. M. Leavens, N. W. Snyder, J. J. Brehany, R. F. Whitman, Engineering and Economic Analysis *of* Waste to Energy Systems, a report prepared by Ralph M. Parsons Co. for the EPA Industrial Environmental Research Laboratory, Cincinnati, Ohio, June 1977.
11. Schulz, H., J. Benziger, B. Bortz, M. Neamatalla, G. Tong, and R. Westerhoff, Resource Recovery Technology *for* Urban Decision Makers, a report to the National Science Foundation by the Urban Technology Center, Columbia University, January 1976.
12. Marsh, Paul, Black Clawson Co., Hamilton, Ohio, telephone communications, February and March 1978.
13. Abert, James C., "Aluminum Recovery . . . A Status Report, " *NCRR* Bulletin, Spring and Summer 1977.
14. Alter, H., "European Materials Recovery Systems, " Environmental Science and Technology, vol. II, no.5, May 1977.
15. Alter, H., National Center for Resource Recovery, Inc., telephone communication, August 1978.
16. Bailie, R. C., and D. M. Doner, "Evaluation of the Efficiency of Energy Resource Recovery Systems, " Resource Recovery and Conservation, vol. 1, no. 2, October 1975, pp. 177-187.
17. Alter, H., National Center for Resource Recovery, Inc., telephone communication, December 1977.
18. Rigo, H., Systems Technology Corporation, Xenia, Ohio, telephone communications, January and April 1978.
19. Gordian Associates Incorporated, Environmental Impacts *of* Production *of* Virgin and Secondary Paper, *Glass*, and Rubber Products, Report no. SW-128c U.S. Environmental Protection Agency, 1976.
20. Ziegler, R. C., S. M. Yaksich, R. P. Leonard, and M. VanLier, Environmental Impacts *of* Virgin and Recycled *Steel* and Aluminum, Final Report (SW-117c) done by Calspan Corporation for the U.S. Environmental Protection Agency, 1976.
21. Bravard, J. L., H. B. Flora, and C. Portal, Energy Expenditures Associated with the Production and Recycle *of* Metals, Oak Ridge National Laboratory Report ORNL-NSF-EP-24, November 1972.
22. Williams, Robert, H., (editor), The Energy Conservation Papers, ch. 5, "Potential Energy Conservation from Recycling Metals in Urban Solid Wastes," authors, W. E. Franklin, D. Benersky, W. R. Park, and R. G. Hunt, Ballinger Publishing Co., 1975.
23. Levy, S., EPA, and H. Rigo, Systems Technology Corporation, telephone communications, January 1978.
24. European Waste-to-Energy Systems, An Overview, Department of Energy Report

No. CONS-2103-6 by Resource Planning Associates, Inc., June 1977.

25. Walter, D., Department of Energy, telephone communication, February 1978.
26. EPA, Environmental Assessment of Waste-to-Energy Processes: Source Assessment Document, EPA 600/7-77-091, August 1977.
27. Burch, William, EPA, telephone communication, April 1978.
28. 40 CFR, subpart E, 60.50, Standards of Performance for Incinerators, 1977.
29. Willey, Cliff, Maryland Environmental Service, telephone communication, January 1978.
30. Freeman, H. M., and R. A. Olexsey, "Energy from Waste: An Environmental Solution that Isn't Problem Free, " News of Environmental Research in Cincinnati, EPA, July 1977.
31. EPA, "Evaluation of the Ames Solid Waste Recovery System, Part 1, Summary of Environmental Emissions: Equipment, Facilities, and Economic Evaluations, " EPA-600/2-77-205, November 1977.
32. *Solid* Waste Report, Nov. 21, 1977 and Dec. 19, 1977, Silver Spring, Md.
33. Diaz, L. F., C. Riley, G. Savage, and G. Trezek, "Health Aspect Considerations Associated with Resource Recovery" Compost Science, summer 1976, vol. 17, no. 3.
34. Kniseley, R., DOE Ames Laboratory, telephone communications, January and April 1978.
35. Cimino, J. A. "Health and Safety in the Solid Waste Industry, " American Journal of *Public Health*, January 1975, vol. 65, no. 1.
36. Duckett, J., National Center for Resource Recovery, Inc., personal communication, December 1977.
37. Duckett, E. J., "Physical/Chemical Analyses of Dusts at the Equipment Test and Evaluation Facility, " Technical Report No. TR 78-1, National Center for Resource Recovery, Inc., Washington, D. C., March 1978.
38. ERDA, "Assessment of Explosion Hazards in Refuse Shredders, " Factory Mutual Research Corporation, ERDA-76-71, June 1976.
39. Rogers, K., Vice President for Resource Recovery, Combustion Equipment Associates, N. Y., telephone communications, January and August 1978.
40. Federal Register, vol. 42, no. 213, Friday, Nov. 4, 1977, pp. 57747-57748.
41. Lovins, A. B., *Soft* Energy *Paths:* Toward a Durable Peace, Ballinger Publishing Company, 1977.
42. Jackson, J. R., and W. S. Johnson, Commercial Energy *Use:* A *Disaggregation* by *Fuel*, Building Type, and End Use, Oak Ridge National Laboratories, ORNL/CON-14, February 1978,
43. Friedricks, M., DOE telephone communications, March 1978.
44. Coyle, W., J. Osborne, and M. Friedricks, DOE, personal communication, February 1978.
45. Current Population Reports, Population Estimates and Projections, series P-25, Nos. 649-698, U.S. Bureau of the Census, May 1977.
46. Current Population Reports, Population Estimates and Projections, series P-25, no. 709, September 1977.
47. *The Role of* Demonstrations in Federal *R&D* Policy, OTA, Program on R&D Policies and Priorities, Washington, D. C., July 1978.
48. Alter, H., and B. Crawford, Materials Recovery Processing Research, A Summary of Investigations, U.S. EPA Contract 67-01-2944, October 1976.

Chapter 6

Economics of Centralized Resource Recovery

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Chapter 6

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

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	

aLiterature estimates inflated to 1979 dollars using Engineering News *Record* Construction Cost Index.
bCost for 750 tpd reported in (9) adjusted to 1,000 tpd using scale factor in reference (8).
cCosts 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:

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

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:

$$\text{capital cost} = \frac{[\$30\ 000000][0.1]}{(365 \text{ days}] \times [1{,}000 \text{ tons/day}][0.70]} = \$11.74/\text{ton}$$

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)

Technology	Reference	Year	Operating cost[a] ($/ton) 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-II®)	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	9.91-10.14[b]	10.69-10.94	10.40
	22	1978	9.57[c]	9.57	

[a]Literature estimates inflated t. 1979 dollars using implicit mice deflater. Averages-rounded to nearest 10 cents
[b]200-tpd plant.
[c]220-tpd plant.

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

Technology	Estimated costs ($/ton) Capital[a]	Operating[b]	Total[c]
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-II®)	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 recovery[d]	10.10	10.40	20.50

[a] Based on average investment from table 43. capital recovery factor 0.1. capacity utilization factor O 70
[b] based on average operating costs from table 44.
[c] Actual cost of any particular project may differ markedly from these estimates
[d]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 Costa ($/ton)	Energy revenues[b] ($/ton)	Ferrous revenues b ($/ton)	Minimum tipping fee[c] ($lton)
Waterwall incineration to steam.	$26	$9-17	—	$ 9-17
Refuse-derived fuel with materials recovery.	15	5-9	1-3	4-1o
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
cTotal costs minus revenues
dAssumed 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.

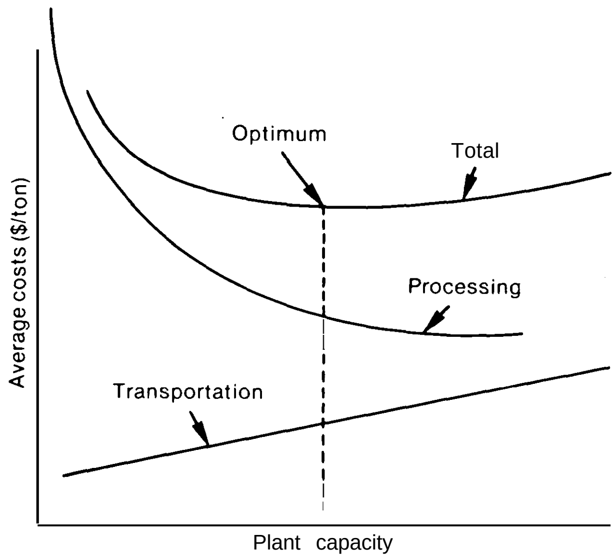
From an economic point of view, an optimum resource recovery system is the one that handles a region's wastes at lowest net cost per ton. (The net cost is the difference between processing and transportation costs on the one hand and product revenues on the other.) If unit revenue is independent of plant 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 l,500)-tpd capacity for all technologies, with

Figure 5.—Optimum Resource Recovery Plant Capacity



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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
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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

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.

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

*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.

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.

Chapter 7

Institutional problems in Centralized Resource Recovery: Issues and Policy Responses

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Institutional Problems in Centralized Resource Recovery: Issues and Policy Responses

Introduction

The Nature of Institutional Problems

Change in a society is often measured by changes in the number and character of its institutions. Yet, because institutions reflect and define the way things are done, their very existence can be a barrier to technological change. Institutions such as government agencies, trade associations, and citizen groups that operate outside market arrangements often constrain actions that are desirable from an economic or technical perspective. Others, such as research institutions, support technological change by providing new ideas and people trained to accept and implement them. This chapter focuses on those institutions that can act as barriers to resource recovery, particularly centralized resource recovery where institutional barriers are highest.

Problems caused by institutions are not unique to resource recovery. They arise whenever a new technology is adopted, especially when the user is in the public sector or must work closely with the public sector, as is the case with law enforcement, education, information processing, mass transit, and also resource recovery.

Existing institutional barriers pose problems for initiating or improving resource recovery, recycling, and reuse. Some of these may be more difficult to solve than the technological and economic problems discussed elsewhere in this report. Some may even be insurmountable; the only approaches may be to circumvent them by adapting technology to them, by adopting new economic incentives or disincentives, or by establishing entirely new institutions.

This chapter addresses these specific questions:

- What is the importance of risk as an institutional issue in resource recovery?
- What are the major institutional problems for resource recovery?
- What is the origin or nature of each of these problems?
- What Federal policcv options are available for addressing ‘these problems and how well might they work?

Risk as a Source of Institutional Problems

Centralized resource recovery is an uncertain activity that poses risks to those involved in it. * The large capital investments required make it a particularly risky venture. Managing this risk is at the heart of a number of its institutional problems.

A potential investor in centralized resource recovery, whether public or private, faces at least five separate sources of uncer-

*An uncertain activity is one Whose outcome Cannot be predicted exactly. The risk is a measure of the loss that would occur if the outcome is a failure—the greater the investment at a given level of uncertainty, the greater is the risk.

tainty which put that investment at risk. Public officials face political risks that arise in part, from these same uncertainties.

- Technical uncertainty—will the technology perform reliably and yield products with expected quality while keeping effluents at acceptable levels?
- Cost uncertainty—can the facility be built and operated for the projected costs?
- Revenue uncertain y—will potential customers purchase the available quantities of recovered materials and energy at expected prices?
- Waste uncertainty—will municipal solid waste (MSW) be delivered to the facility in expected quantity and with expected composition?
- Environmental uncertainty—will environmental standards change as a result of political action or if new hazards are identified?

Each of the parties to a resource recovery decision would like to reduce his risk either by reducing the overall level or by transferring it to the other parties. While institutions can provide the means to do both, they can also be barriers to effective risk reduction or risk sharing.

Some Approaches to Risk Management

A resource recovery investor can reduce financial risk in several ways:

- Diversify by means of spreading the risk by building several, perhaps smaller, facilities using different technologies with different technical uncertainties, thus reducing the overall economic risk but not the technical uncertainties of each facility.
- Use only proven technologies, thus reducing the technical and cost uncertainties.
- Seek long-term contracts for fixed quantities of inputs and for products of specified quality or composition, thus reducing the waste and revenue uncertainties.
- Use technologies with advanced environmental controls or that produce "zero-discharge, " thus reducing the environmental uncertainties.
- Seek a Government subsidy, thus reducing the economic risk, but not the economic uncertain y.
- Delay while performing research and development (R&D) or waiting for better technology to be developed by someone else, thus reducing the technical uncertainty.

Each of these approaches affects the balance sheet cost* of resource recovery, its total cost to society, and the distribution of risk among the parties-at-interest. For example, using only proven technologies reduces the economic and technical uncertainties for all the parties involved. This approach, however, could carry a high price if proven technologies are expensive. Using the approach of Government subsidy, the risk of loss to the investor is decreased by transferring it to the Government. Thus, the owner's balance sheet cost of resource recovery declines, even though the total cost to society remains the same. Similarly, long-term contracts for delivering waste of a guaranteed quantity and composition can probably be made with a community only at a lower tipping fee than it would otherwise be willing to pay. The community would want to pay less because it would forego the ability to adapt to future circumstances by offering such a guarantee. Each of these examples shows that reducing risk has a real price that someone or some other institution must be willing to pay. This is the reason that risk is an institutional problem.

Institutional Problems in Centralized Resource Recovery

Table 49 lists 17 institutional problems that frequently arise in the establish-

*A balance sheet cost is the cost of resource recovery calculated as the difference between a plant's income and its expenses. Subsidies or externalities paid by or to other parties are not included in its calculation,

Table 49.—Institutional Problems in Centralized Resource Recovery

information Problems
1. Underinvestment in research and development.
2. Inadequate information at the local level.

Jurisdictional Problems
3. Fragmented and overlapping State and local jurisdictions.
4. Cost sharing among communities.
5. Mixture of private and public roles in managing MSW.
6. Responsibility for and ownership of waste after discard (“flow control”).
7. Limitations on interjurisdictional waste shipment or disposal.
8. Overlapping Federal agency jurisdictions.

Implementation Problems
9. Limited capability of local governments to issue bonds.
10. Cooperation of local waste collectors and haulers.
11. Creation of local monopolies.
12. Insufficient definition of health, safety, and environmental standards for resource recovery plants.
13. Siting of facilities.

Marketing Problems
14. Inadequate or nonexisting standards of performance for recovered products.
15. Limited authority of local governments to enter into long-term sales contracts,
16. Electric utility rate regulation that discourages use of new fuel sources.
17. High freight rates for shipping MSW and recovered materials.

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ment of centralized resource recovery. These problems are grouped under four main topics: information, jurisdictional, implementation, and marketing. Each is discussed in the following section. Subsequent sections discuss policies that could be used to address these problems.

Information Problems

1. UNDERINVESTMENT IN RESEARCH AND DEVELOPMENT

Although a number of demonstration facilities and a few commercial resource recovery plants are now in operation, considerable uncertainty remains concerning their technical and economic performance. Subsystems for recovery of aluminum, glass, and mixed nonferrous metals have not been operated commercially, and recovery of fiber suitable for papermaking has yet to be accomplished. Advanced energy recovery systems such as pyrolysis remain at the demonstration stage. Much still needs to be learned about the environmental and occupational health aspects of resource recovery plant operation. (See chapter 5.)

Studies of the process of technological innovation have shown that from a social point of view private firms tend to underinvest in R&D, especially for technologies that are intended for sale in the disaggregated market made up of local governments. Because knowledge can be used by anyone, once it is obtained, firms cannot usually gain all the returns on an investment in R&D. Thus, one outcome of a market economy is that not all technological opportunities are taken advantage of, nor all technical problems solved, without some level of Government participation.

2. INADEQUATE INFORMATION AT THE LOCAL LEVEL

From State or local points of view, the problems of technical and economic uncertainty are compounded by the complexity of what needs to be known to plan and operate resource recovery systems. Specialized and sophisticated engineering, marketing, legal, and operating skills are all required. State or local governments cannot be expected to have this expertise in-house, or even to be able to interact knowledgeably with consultants, vendors, Government agencies, or special interest groups. Furthermore, local citizens and interest groups generally do not have effective access to expertise about complex technologies such as resource recovery.

The problem of inadequate information is further complicated by the tendency to oversell sophisticated new resource recovery technologies. This can be done both by some of a technology’s proponents and by groups that advocate resource recovery as an alternative to legislation which would discourage waste generation such as mandatory beverage container deposits or the product charge. The financial stakes in resource recovery are high—much higher than the cost of plant construction alone. Local officials are in a vulnerable position. On the one hand they are subjected to technology oversell and on the other to opposition by some local trash haulers, to skepticism by some environmentalists, and to resistance to landfills and resource recovery plants by some citizens. An unbiased and objective source of information would be helpful.

Jurisdictional Problems

3. FRAGMENTED AND OVERLAPPING STATE AND LOCAL JURISDICTIONS

Responsibility for solid waste collection and disposal has traditionally been at the local government level, often provided competitively by the private sector or through a franchise system. Except for large cities, however, adequate environmental regulation and effective resource recovery programs often require cooperation among several local government units as well as between State and local governments. For example, in the absence of statewide or regional solid waste environmental control programs, open dumping in unincorporated areas may not be subject to any control.

Furthermore, in the metropolitan areas in which the waste disposal problem is often most serious, it is not uncommon for towns and cities, counties, regional planning councils, and special waste or water management districts to all be involved in some aspect of operating or regulating the collection and disposal of MSW. Frequently, these different jurisdictions are in conflict on many fronts; cooperation to accomplish resource recovery is only one of many problems they face. These conflicts can rarely be resolved by assigning full responsibility to any one group. Consequently, accomplishing resource recovery requires expensive, time-consuming, and complicated planning and coordination.

4. COST SHARING

Perhaps the most difficult local jurisdictional problem is to devise an equitable and effective method for sharing the costs of transportation, transfer, and processing in a centralized resource recovery system that involves several communities. As noted in chapter 6, an economically optimal system for a region would process all of its wastes at the lowest net cost. Some communities, however, may incur higher costs under the regionally optimal system than they would under some alternative. The result is that it may be necessary for those communities whose costs are reduced by resource recovery to appear to be subsidizing those that would otherwise face higher costs, if the region as a whole is to be served at lowest cost.

An example may help clarify the cost-sharing problem. Suppose that two equal-sized communities, A and B, could form a region for the purposes of centralized resource recovery. Suppose further that waste disposal using landfill costs $5 per ton in A and $10 per ton in B, and that a joint resource recovery system costs $7 per ton (net cost). Only B would benefit economically from resource recovery at $7 per ton. Therefore, A, which would not benefit, would probably be disinclined to join in. One approach would be for B to pay an additional $2 per ton to A as an inducement to join the system. Thus, the final net cost to B would be $9 and to A $5 per ton: B would save $1 per ton and A would pay the same as for landfill. Another approach would be for B to pay $2,50 per ton to A. This would result in a net cost of $9.5o per ton to B and of $4.5o per ton to A. With this alternative, both A and B end up with a net savings of $0.50 per ton using resource recovery. The problem with these monetary inducements is that B appears to subsidize A. Even though this is not actually the case, it is likely to be a politically unacceptable solution, particularly if B is an old, crowded city and A is its affluent suburban neighbor.

It is possible that two communities could come to an agreement of the kind discussed above. A real region, however, which can be made up of 100 or more independent communities, will face great difficulties in attempting to devise an acceptable cost-sharing formula that would enable it to use its optimal (lowest net cost) system. Yet, failure to adopt the lowest cost system may price resource recovery out of the market, (See chapter 6.)

5. MIXTURE OF PRIVATE AND PUBLIC ROLES IN MANAGING MSW

In most communities both public agencies and private firms have operating responsibilities for collecting, processing, and disposal of MSW. Frequently, private firms are given franchises to collect waste, while landfills may be operated by public agencies, sometimes in competition with private firms. Resource recovery plants may operate as private ventures, as public ventures, or as public ventures operated by private firms under contract.

In regions where resource recovery would be economically attractive, different communities may have different mixes of public/private activities, which may greatly complicate agreeing on the arrangements for resource recovery. Existing private operators are often concerned about losing the opportunity to compete for waste business, while existing public agencies resist losing public jobs to private firms. Private landfill operators are wary of competition from a new public or private resource recovery plant, especially if it enjoys a subsidy unavailable to them.

6. RESPONSIBILITY FOR AND OWNERSHIP OF WASTE AFTER DISCARD ("FLOW CONTROL")

Some resource recovery project owners have sought local ordinances or exclusive contracts that would mandate delivery of all of a community's solid waste to a designated resource recovery plant in order to ensure the economic solvency of the plant. For example, in Wisconsin the law authorizes the Wisconsin Recycling Authority to require municipalities to deliver all MSW to its facilities.(1) Such requirements, called "flow control," prohibit licensed private collectors from skimming off the high-value wastes for sale to scrap processors or from seeking the most economic means of disposal, including landfill. Flow control laws are different in intent from ordinances that prohibit unlicensed collectors from scavenging waste placed at the curb for collection.

The purposes of flow control requirements are often to forestall establishing separate collection programs after a plant is built or to eliminate competition by landfills for disposal. Thus, attempts to mandate flow control are usually opposed by private collectors, landfill operators, and private firms as well as by citizens groups who support separate collection programs. (See chapter 4.)

A new separate collection program, if successful, can seriously reduce the revenues of existing resource recovery plants. As shown in chapter 4, however, if a separate collection program is in place or properly planned for, it need not harm centralized resource recovery economically. Likewise, environmentally sound, economically competitive landfill should always be considered in waste management plans. Thus, flow control requirements, which effectively shift risk from the resource recovery plant owner to other private and public parties, appear to serve no public purpose.

In a recent case in Minnesota, a court ruled that such an ordinance requiring use of a particular landfill was an unreasonable exercise of State power since its purpose was to secure the economic health of a particular project rather than to protect health and safety.(2) An ordinance requiring delivery of all wastes to a resource recovery facility in Akron, Ohio, is under court chaIIenge by the National Solid Wastes Management Association.(3)

7. LIMITATIONS ON INTERJURISDICTIONAL WASTE SHIPMENT OR DISPOSAL

Some State and local governments have prohibited transfer of waste into or across their jurisdictions. While such laws have been oriented toward limiting the use of land in one jurisdiction for disposal of another jurisdiction's wastes, they also serve as a barrier to regionalized resource recovery. New Jersey's law prohibiting importation of waste into the State was upheld by the New Jersey Supreme Court against a challenge that it poses an unconstitutional interference with interstate commerce,(4) but was overturned by the U.S. Supreme Court under a challenge by the City of Philadelphia on the same grounds.(5) The essence of the Court's ruling is that a restriction on waste shipment could be justified to protect public health and safety but that it would be constitutional only if it were applied to wastes from all sources. Application only to out-of-State waste is unconstitutional restraint.

8. OVERLAPPING FEDERAL AGENCY JURISDICTIONS

Concern has been expressed that too many agencies are involved and that the Government fails to speak with a single or coherent voice regarding resource recovery. Federal responsibility for various aspects of MSW management, including resource recovery, is vested in several agencies whose objectives overlap and are sometimes in conflict. These include the Environmental Protection Agency (EPA), the Department of Energy (DOE), the Bureau of Mines (BOM), the National Bureau of Standards (NBS) and other branches of the Department of Commerce (DOC), and the Department of Housing and Urban Development (HUD). Several other Federal agencies have indirect influence over resource recovery, including the Departments of the Treasury and of Defense, the Occupational Safety and Health Administration (OSHA), the Federal Trade Commission (FTC), and the Interstate Commerce Commission (ICC). Advisory or policy roles are also played by the Office of Management and Budget, the Council of Economic Advisors, and the Councils on Environmental Quality and on Wage and Price Stability.

Implementation Problems

9. LIMITED CAPABILITY OF LOCAL GOVERNMENTS TO ISSUE BONDS

Financing capital improvements has become a major problem for many American cities that are at or near their statutory limits on bonded indebtedness or that have poor credit ratings that limit sales. The presence of such communities in a region can be a serious barrier to resource recovery. Furthermore, the Internal Revenue Service (IRS) has been reluctant to certify pollution control revenue bonds for the construction of resource recovery plants. Favorable rulings on such certification could save several percent on the cost of capital for resource recovery.

10. COOPERATION OF LOCAL WASTE COLLECTORS AND HAULERS

Local private waste collectors and haulers tend to view resource recovery skeptically. Many private collectors are also in the landfill business and view resource recovery as a direct competitor. Others fear a squeeze between the sum of higher disposal fees and increased transportation costs to distant resource recovery plants on the one hand, and unwillingness of customers to pay higher rates on the other. Still others are concerned about flow control measures that may accompany resource recovery. (See discussion above on flow control.)

11. CREATION OF LOCAL MONOPOLIES

The private approach to financing, ownership, and operation of resource recovery facilities poses another kind of institutional problem: creation of a local monopoly over solid waste disposal services. The problem is compounded because this monopoly would control an activity that has an essential public health objective. In this event, it may be necessary to consider extending public utility regulation to resource recovery in order to limit monopolistic behavior in pricing and services.

12. INSUFFICIENT DEFINITION OF HEALTH, SAFETY, AND ENVIRONMENTAL STANDARDS FOR RESOURCE RECOVERY PLANTS

Currently, the status of resource recovery plants as generators of air, water, and noise pollution; bacterial and viral disease vectors; and safety hazards to workers and the community is unclear, (See chapter 5.) Recent experiments suggest that air pollution from some systems may be significant unless controlled carefully. Disease problems, if any, are not well understood. From the institutional perspective, however, the most significant point is that health and environmental performance standards for resource recovery facilities of various types and sizes have not yet been established. The absence of air quality standards for heavy metals and pathogens, for example, combined with the possibility that such emissions from resource recovery may be regulated in the future, is a source of economic uncertainty for potential investors in such systems. Presumably OSHA'S General Duty Clause(6) provides a basis for maintaining a healthy environment in such plants, but it also leaves room for uncertainty about the appropriate levels of control. Until all the relevant standards are defined, investment in resource recovery will be unduly uncertain.

13. SITING FACILITIES

Attitudes toward resource recovery vary considerably among environmentalists, conservationists, and other interested citizens. Some view resource recovery skeptically as a high-technology approach to waste disposal that would foreclose opportunities to reduce waste, to conserve materials, or to adopt source separation programs. Others view it as an environmentally sound solution to the waste disposal problem. Still others, perhaps most, have come to view resource recovery as one option among several that may play a role in a well-designed program.

Nevertheless, citizens rarely want to have such a plant in their neighborhood. Thus, siting facilities such as transfer stations, primary and secondary processing plants, and residue disposal landfills pose problems for resource recovery systems. A project in St. Louis foundered, in part, on its inability to site one of four proposed transfer stations. Resource recovery plants are industrial complexes that require utiIities; access by truck and, in some cases, rail; parking and storage space; and space for landfill of residuals or of wastes in the event of an emergency shutdown. They are restricted to industrially zoned parcels and must meet various environmental requirements. Often this includes an environmental impact statement. Even in the absence of substantive legal barriers to the selection of a site, objectors may be able to delay or stop site selection or facility construction by litigating over the procedures used.

In multicommunity projects, siting is further complicated by the conflict between the wishes of some interests to attract resource recovery to their area as a tax-paying industrial development and of others to avoid establishment of a project nearby that would bring in waste from distant communities. Problems of this type have emerged with a variety of public projects in which the costs are incurred at the local level but the benefits are regional.(7)

Marketing Problems

Marketing recovered materials and energy requires that customers be found for them at satisfactory prices. Nevertheless, various institutional barriers may make recovered products less marketable than would be the case if only price mattered, Two of the problems listed in table 49; inadequate or nonexisting standards of performance for recovered products (table 49, No. 14); and high freight rates for shipping MSW and recovered materials (table 49, No. 17) are discussed in chapter 3, to which the reader is referred for details. Two other marketing problems are discussed here.

15. LIMITED AUTHORITY OF LOCAL GOVeRNMENTS TO ENTER INTO LONG TERM SALES CONTRACTS

Communities in some States are forbidden to enter into long-term contracts for the sale of waste or for the disposition of products from resource recovery plants. For example, contracting authority may be limited to 1 year or to the term of the city council or the mayor. Economically sound resource recovery plants require much longer contracts, often for 10 years or more. If the limits on contracting authority were removed, the interests of a community could be preserved by providing for floor prices, escalation clauses, profit-sharing, or renegotiation options. Such limits imposed by State law or city charter are major barriers to resource recovery.

16. ELECTRIC UTILITY RATE REGULATION THAT DISCOURAGES USE OF NEW FUEL SOURCES

Traditionally, electric rates are set to permit a reasonable rate of return on invested capital. As operating costs change, especially upward, the delay between increased costs and the approval of rate increases can reduce the effective rate of return below that allowable. This "regulatory lag" can cause utilities to avoid taking risks that might result in unanticipated costs. Furthermore, in recent years many States have granted fuel adjustment clauses, which permit automatic rate increases whenever utility fuel costs increase. This has weakened the incentive for utilities to seek lower cost fuels. In addition, many utilities are faced with a shortage of capital caused by the higher costs of new generating equipment coupled with inadequate financial performance. Thus, they are reluctant to enter into any program thr would put the productivity of existing equipment at risk. Finally, the fact that utilities are required by law to provide reliable service also makes them less willing to try new approaches.

All of these utility rate considerations have combined to make utilities, one of the prime potential markets for recovered energy, very hesitant to use refuse-derived fuel (RDF) or other solid waste fuel forms. Even if RDF combustion technology were well understood, some of these factors would continue to operate to the disadvantage of resource recovery. This assessment of the situation is similar to that of a DOE contractor(8) and of an Electric Power Research Institute conference.(9)

Federal Options for the Institutional Problems

Three overall considerations should guide Federal action to solve institutional problems in resource recovery. First, Federal programs should recognize that there are wide differences in local conditions across the Nation. Therefore a wide range of local responses and arrangements should be accommodated,

Second, Federal programs should recognize that centralized resource recovery is only one of a variety of legitimate approaches to management of MSW, and that such programs should not be designed to promote one approach to the exclusion of others. The paramount concern should remain protection of public health and safety through cost-effective waste disposal.

Third, the nature of Federal programs to overcome institutional barriers should change as centralized resource recovery matures from an experimental to a fully developed technology. As local government experience with resource recovery accumulates, the need for a Federal presence will decline.

The Federal Government has only limited authority to directly address most of the institutional problems discussed above. In some cases it can offer inducements to do so to the State and local governments, which do have the necessary authority. In other cases, it can offer direct financial assistance to help reduce the uncertainties and risks that underlie some of the issues. In a few instances, the Federal Government can act directly to remove institutional barriers.

Since the Federal Government does not have a role in the implementation of resource recovery per se, its impact can be felt principally through Federal inducements to State and local governments. The Resource Conservation and Recovery Act of 1976 (RCRA) reflects this approach, coupled with a program to close open dumps and regulate landfills, again through inducements to States to act.

Table 50 lists three categories of policy options available to the Federal Government for helping overcome institutional barriers to centralized resource recovery. Some of these policy options have been discussed in other chapters as ways to overcome technical and economic uncertainties or to deal with limitations on resource recovery; here they are discussed only in connection with institutional barriers.

Table 50.—Available Federal Options Applicable to Institutional Problems in Centralized Resource Recovery

Direct Federal Actions to Remove Barriers

- Fund research, development, and demonstration projects.
- Education and training.
- Technical assistance to State and local governments.
- Coordinate or consolidate Federal programs.
- Certify resource recovery plants as eligible for pollution control revenue bond financing.
- Promulgate health and environmental standards for resource recovery plants.
- Assist in, or mandate, development of performance standards for recovered materials and energy.
- Require utility rate regulation favorable to use of energy from waste.
- Adjust railroad freight rates for recovered resources.

Federal Financial Assistance to Reduce Uncertainty and Risk

- Construction subsidies: e.g., grants, tax credits, low-interest loans, loan guarantees.
- Operating subsidies: e.g., recycling allowance, product subsidy, tax credit for wages paid.

Federal Inducements to States and Local Governments (Federal funds for statewide solid waste planning contingent on various State actions)

- Regionalization of planning.
- Citizen participation in planning.
- Adoption of siting procedures.
- Change utility regulation.
- Elimination of barriers to long-term contracts.
- Prohibit waste shipment barriers.
- Mandate cost-sharing formulas.
- Eminent domain for resource recovery facilities.
- Regulate prices and conditions of service for recovery monopolies.

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Effectiveness of the Federal Policy Options

Table 51 shows the primary relationships among the policy options and problems. Note that several options may be used to address one problem, and that some address several problems simultaneously. Table 51 also references the parts of RCRA in which various options appear. The following paragraphs explain the roles of the various options.

Direct Federal Actions

FUND RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROJECTS

Federal R&D funds primarily serve to fill gaps in private funding. They help to reduce technical uncertainty and thus may reduce economic risk. Demonstration project funds may also reduce technical uncertainty and economic risk, and in addition may help show State and local people that resource recovery can work, if it does.

There is currently, however, a significant amount of privately funded R&D in new resource recovery processes, as well as several privately funded demonstration and commercial plants. Furthermore, much of the research that needs to be done in commercializing resource recovery requires a kind of "learning by doing. " This is best accomplished by building and operating a series of similar facilities, rather than by R&D programs. These observations both suggest that

Table 51.— Relationship of Federal Options to Reducing Institutional Barriers to Centralized Resource Recovery

Policy options / Problem area	Direct Federal action									Federal action to reduce uncertainty and risk		Federal inducements to State and local governments								
	Research, development, & demo. funds	Education & training	Technical assistance	Federal coordination	Revenue bond certi[illegible]	Promulgate env. health safety standards	Set performance standards	Utility rate reform	Freight rate reform	Constr[illegible] subsidies	Operating subsidies	Regional planning	Citizen participation	Siting procedures	Utility rate reform	Allow long-term contracts	Prohibit flow control	Mandate cost-sharing	Eminent domain	Regulate resource recovery monopoly
RCRA reference	4008, 8001, 8004, 8006	7007	2003, 2006, 4008	6003, 6004			5002					4006, 4008	7004			4003				
1. Underinvestment in R&D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Inadequate information	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. Fragmented State and local jurisdictions	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4. Cost-sharing	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5. Private/public mix	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6. Flow control	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7. Limits on waste shipment	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8. Overlapping Federal jurisdictions	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9. Limited bondina capability	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10. Cooperation of collectorsihaulers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11. Resource recovery monopoly	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12. Insufficient health & environmental regulation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13. Facility sitina	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14. Inadequate performance standards	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15. Limits on long-term contracts	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16. Risk avoidance by utilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17. High freight rates	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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the Federal role in R&D might be limited to fundamental investigations into the underlying science and technology of mechanical separations and size reduction, to measurement of properties of recovered materials and fuels, and to R&D on health, safety, and environmental problems. (See chapters 4 and 5 for discussion of R&D needs and activities in resource recovery.)

Under the Resource Conservation and Recovery Act (RCRA), EPA, DOE, and DOC are given responsibilities for research, development, and demonstration in resource recovery. EPA and DOE have requested and received appropriations for this activity. Funds authorized by RCRA have not been appropriated to support the research on the properties of recovered materials and energy at NBS. In addition to these activities under RCRA, the Bureau of Mines in the Department of the Interior has done research on resource recovery under the authority of its organic act.

EDUCATION AND TRAINING

Education and training in resource recovery should have positive impacts, whether directed at technical and operating professionals and workers, citizens, competitors, or potential objectors. Not only will decisions be more well-informed, and therefore improved; but cooperation of waste collectors and haulers, citizens, environmentalists, and neighbors of facilities will also be improved. Better understanding should help avoid construction delays and technical oversell. Cost-sharing arrangements can be worked out more easily if decisionmakers understand the benefits to be gained.

Under section 7007(c) of RCRA, EPA is to make an investigation of employment needs, opportunities, and barriers in solid waste disposal and resource recovery. This survey could help determine part of the national need for specialized training programs in resource recovery.

TECHNICAL ASSISTANCE TO STATE AND LOCAL GOVERNMENTS

One approach to dealing with the problem of inadequate information and understanding of resource recovery at the State and local levels is for the Federal Government to provide direct technical assistance, especially through knowledgeable people. RCRA section 5004 provides for DOC " . . . to evaluate the commercial feasibility of resource recovery facilities . . . and to develop a data base for purposes of assisting persons in choosing such a system. "

RCRA section 2003 provides for EPA to establish Resource Conservation and Recovery Panels. " . . . The Administrator shall provide teams of personnel, including Federal, State, and local employees or contractors (hereinafter referred to as Resource Conservation and Recovery Panels) to provide States and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation. Such teams shall include technical, marketing, financial, and institutional specialists, and the services of such teams shall be provided without charge to States or local government. " EPA has recently published a handbook to guide the implementation of this program.

The provision of technical assistance is based on the beliefs that State and local governments are not well enough informed to make sound decisions about resource recovery and that they lack the necessary personnel to do so. Recent research on technological innovation in the public sector (in areas other than resource recovery) suggests that public officials and staff are often well informed about the existence of new technology but that they lack credible sources of evaluated information.(11) If this is true in the resource recovery area, the Resource Conservation and Recovery Panels can have a major impact on the future adoption of resource recovery if they remain scrupulously objective and responsive to State and local concerns. In particular, they must avoid bias toward or against various approaches and technologies. At the same time, it is important that they not compete with private parties willing and able to provide the same assistance.

Technical assistance might help to improve the general information base and thus aid State and local governments to make sounder decisions about resource recovery systems. In addition, State and local governments might be helped to understand the importance of resolving related problems at the local level, including supervision of waste disposal monopolies, ensuring local collector/hauler cooperation, lowering barriers to shipment of waste across boundaries, overcoming citizen opposition and multi jurisdictional conflicts, and avoiding construction delays.

REQUIRE FEDERAL AGENCY COORDINATION OR CONSOLIDATION FOR RESOURCE RECOVERY

The problem of interagency coordination for resource recovery has been a major concern of Federal agencies. However, diverse Federal responsibilities for resource recovery appear to contribute to healthy competition. If a single agency had full responsibility at the Federal level, an orthodox view of resource recovery might develop. Currently, the perspectives of EPA, DOE, DOC, and other agencies appear to be different. Thus, they encourage critical review of each other's policies and programs.

Under RCRA, responsibility for Federal interaction with State and local governments is centered in EPA. Therefore, individual State and local governments should be able to locate the most appropriate Federal agency to meet their needs through EPA, while a wider access to the Federal Government for various interests is preserved at the national level by the involvement of several Federal agencies.

EPA and DOE are expected to complete a memorandum of understanding regarding their respective roles in planning, demonstrations, and financial assistance for commercializing the recovery of energy and materials from solid waste.(12)

MAKE RESOURCE RECOVERY PLANTS ELIGIBLE FOR POLLUTION CONTROL BOND FINANCING

If IRS were to allow resource recovery facilities to be financed by industrial development bonds, it would help to overcome both the bonded indebtedness limits of cities and the capital shortage faced by electric utilities. Section 103(b)(4)(E) of the Internal Revenue Code provides for an exemption from Federal income taxation for gross income from industrial development bonds issued by States, territories, possessions or any of their subdivisions, or by the District of Columbia for the purpose of financing "solid waste disposal facilities. " Apparently, IRS is reluctant to certify resource recovery plants for financing with tax free bonds under this provision since such plants recover valuable products including fuels and materials. An act of Congress may be needed to clarify the status of resource recovery for purposes of section 103.

PROMULGATE REGULATIONS FOR ENVIRONMENTAL, HEALTH, AND SAFETY PERFORMANCE OF RESOURCE RECOVERY FACILITIES

The absence of clear regulatory standards of performance for resource recovery plants may serve to deter both private and public investment in them, since subsequent modification of existing plants to meet new standards may be costly. Therefore, the Federal agencies involved should carry out the necessary research and monitoring. The results should then be used to promulgate the standards needed for occupational health and safety, air quality, and water quality.

In addition, the status of resource recovery plants under existing air quality regulations is not clear, especially at the State level. In some jurisdictions, some types of small incinerators are effectively banned under State air quality regulations. This is the case in parts of Maryland, for example. Recently, EPA has exempted new recovery facilities from its emission offset policy under the Clean Air Act.(14) This action removes one barrier to their construction in nonattainment areas. *

Setting such standards might help to remove the barriers to shipments of waste for resource recovery across jurisdictional boundaries by providing assurance to communities that their environments would be protected. Citizen acceptance of facilities might be eased, siting limitations lowered, and construction delays averted, if well-enforced, broadly accepted standards were established. Waiver of such standards for resource recovery plants may prove to be counterproductive if it acts to stimulate opposition to new facilities. However, temporary variances for environmental emissions on a case-by-case basis may prove useful to assist in easing the new technologies through the uncertain period of early commercialization.

ASSIST OR MANDATE THE DEVELOPMENT OF PRODUCT PERFORMANCE STANDARDS

If activities in the private sector to develop performance standards for recovered materials and energy were inadequate, the Government might consider promulgation of such standards directly. However, as noted in chapter 3, the development of standards is progressing, and direct Federal involvement is probably unnecessary.

Under section 5002 of RCRA, NBS is to publish guidelines for the development of specifications for recovered materials. DOC is to cooperate with national standards-setting organizations as necessary to encourage the publication, promulgation, and updating of standards for recovered materials.

REQUIRE UTILITY RATE REFORM

Current electric rate regulation provides no incentive to utilities to use energy from waste. The Federal Government could offer direct financial incentives to utilities for this purpose based on, for example, a cash payment for every unit of recovered energy used. Alternatively, the Federal Government could intervene directly in the traditional State province of rate regulation and require States to remove such disincentives as the fuel adjustment clause or to offer such incentives as a higher allowable rate of return on capital required to use energy from waste. (Inducements to the States to do the same thing are discussed below.)

FREIGHT RATE ADJUSTMENT

Adjustment of freight rates for recovered resources is designed to improve their marketability and thus stimulate implementation of resource recovery. However, as the investigations reported in chapter 3 have shown, the potential of reasonable freight rate adjustment to improve markets for scrap is limited, at least in the short run. Thus, this policy cannot be viewed as a major factor in overcoming barriers to resource recovery.

Federal Financial Assistance to Reduce Risk and Uncertainty

OVERVIEW OF SUBSIDIES FOR STATIC AND DYNAMIC PURPOSES

The approach of one class of options is for the Federal Government to offer direct financial assistance to public or private investors in resource recovery in order to reduce the uncertainties and risks they face. These options involve various subsidies of the costs of constructing or operating a resource recovery facility.

There is a subtle but important distinction between: i) a subsidy designed to make a project economically feasible that would otherwise surely not be, and ii) a subsidy designed to reduce the economic risk associated with investing in an uncertain project. In the first case, the technical and economic performances of a proposed project are well known, the costs exceed the benefits, and a subsidy

*Under the Clean Air Act, a nonattainment area is one that is not in compliance with the National Ambient Air Quality Standards.

simply makes it possible to go ahead despite the unfavorable economics. In the second case the technical performance, the costs, or the revenues are not predictable with certainty, although there is reason to expect that the project has a good chance of being successful. In this case, a subsidy can be designed to reduce the potential loss to an investor who takes the risk caused by the uncertainty.

Both kinds of subsidy may be appropriate Federal Government actions depending on the circumstances. For example, subsidizing a project known to be uneconomic may be desirable if significant costs or benefits might accrue to the public that are not reflected on the project balance sheet. This is the case for example with the Federal subsidy of the operating budgets of existing urban mass transit systems. On the other hand, the subsidy of an uncertain project is more likely to occur when a new technology is being tried, which, if successful, could be economically self-supporting, but which, if unsuccessful, could leave the investor facing such a considerable loss that no private investor would be willing to take the risk. This argument was used to justify proposals for American, and later British and French, Government subsidies for the development of the supersonic transport.

Arguments for subsidy of uncertain or risky projects can easily be overstated. Often, the fact that a private investor willing to take the risk cannot be found is a signal that the investment community has judged a project unlikely to succeed. The major exceptions to this rule are: i) cases when government rules or other circumstances prohibit effective risk pooling (say, prohibitions on certain kinds of joint ventures) or set limits on allowable rates of return from risky investments; ii) cases when even if the project were successful and the risk were reduced to zero, it would still justify continuing subsidy in the public interest; and iii) cases when expenditures to reduce technical uncertainty, if successful, produce new knowledge that risk-taking investors cannot effectively capitalize on, i.e., when successful investors might significantly subsidize their own potential competitors. This last case is essentially a restatement of the rationale presented earlier for governmental support of R&D, but extended to recognize that such support is not the only tactic available to the Government to support technological development.

Resource recovery technologies currently fit, to varying degrees, the criteria set forth above, which would justify Federal subsidy for risky projects. First, individual communities, as investors in resource recovery, are unlikely to be able to pool their efforts to invest in risky new technology. Second, communities that might pay private firms for resource recovery are unlikely to consider paying the price for the risk premiums those firms would require in order to justify investing in a risky new technology. Third, some general subsidy of resource recovery may be justified on the grounds of public benefit even when risks are small. Finally, risk-taking communities or private investors, if successful, are likely to find themselves subsidizing both risk-avoiding communities and those firms that would prefer to wait for someone else to take the initial risks. If all parties view the situation this way, no one is likely to undertake the risk.

It is appropriate, then, to consider two kinds of subsidy programs designed to reduce the economic risk of investing in an uncertain resource recovery project: construction and operating subsidies. (Subsidy to enhance the attractiveness of uneconomic but certain investments was analyzed in chapter 6.)

CONSTRUCTION SUBSIDIES

Construction subsidies might be offered as tax credits, cash grants, low-interest loans, or loan guarantees. Each form is appropriate to different circumstances. Construction subsidies would accelerate implementation of resource recovery by communities and/or firms. Increased resource recovery activity should reduce the uncertainty about the technical and economic performance of such plants as experience is gained in building and operating them. This is not to say that such plants will necessarily be proven technically and economically workable, but only that the uncertainty would be reduced.

The availability of construction subsidies should help local communities overcome some of their jurisdictional conflicts and cooperate on cost sharing in order to qualify for the subsidies. At the same time, these subsidies can distort the tradeoffs among various approaches. For example, their availability would tend to make smaller plants more attractive and thus would enable communities to avoid such conflicts by going it alone. Local citizens might be more inclined to accept resource recovery if the Federal Government were paying part of the cost. This might help avoid litigation-related construction delays. Subsidies would help communities afford plants otherwise out of reach due to debt limits.

Tax credits are of no use to public owners who pay no taxes and are of little interest to resource recovery firms unless they have taxable income from other areas of business as well. Thus, tax credits favor established, diversified firms. Loan guarantees require no immediate expenditure of public funds, and if a project is successful may involve no outlays at all. However, loan guarantees are designed to spread economic and technical risk by insuring the financial backers of a project against its failure and subsequent default. Thus, one undesirable effect of loan guarantees is to reduce the discipline imposed by the financial community and, in a sense, to insure the resource recovery plant builder against his own mistakes.

Low-interest loans are more effective in offsetting market uncertainty than technical uncertainty. If a project fails to work technically, the holder of a low-interest loan still has to pay off his loan, albeit at a somewhat lower cost, with the risk of having no revenues at all with which to pay. Cash grants are more effective in addressing technical uncertainty than are low-interest loans, since the investor/operator faces a lesser risk if he has to pay off a smaller principal in the event that the project is a technical failure and produces no revenues. Beyond these technical considerations, the selection of a subsidy mode is often a political choice as well as an analytic matter.

OPERATING SUBSIDIES

Operating subsidies can include the recycling allowance (see chapter 8), the product subsidy, and tax credits for wages paid. They would have some of the same impacts as construction subsidies. They are, however, probably a weaker inducement to implement resource recovery because they do not overcome the municipal indebtedness barrier and because their impact is felt in the future rather than as a present reduction in initial investment. If operating subsidies are pegged to revenues, a plant operator will find them less certain than construction grants or low-interest loans. However, as a supplement to revenues when scrap prices are low, they could be a partial substitute for the long-term contracts that otherwise would be required to ensure the economic viability of a project. A tax credit for wages paid new employees hired to do recycling work would tend to stimulate the hiring of resource-recovery workers by the private sector, and would tend to favor labor-intensive approaches (small-scale incinerators, source separation) over capital-intensive large-scale resource recovery.

The Federal Government might attempt to reduce the economic uncertainty around resource recovery by operating a stockpile for various recovered resources in order to stabilize their prices. This option would not be applicable to paper or RDF, which have limited storage life. Such an option maybe attractive in view of the great fluctuations in price and demand for scrap noted in chapter 3. Like all counter-cyclical economic stockpiles this one would face heavy political pressure. Resistance would be offered by scrap dealers to sales from the stockpile in periods of high prices and resistance to purchases for the stockpile would be offered by scrap users in periods of low prices. (See chapter 3 for additional discussion of stockpiles for recovered resources.)

Federal Inducements to State and Local Governments

The previous sections have presented a number of direct Federal alternatives for addressing institutional problems in resource recovery. A number of other approaches can be taken indirectly by requiring State and local governments to take various steps in order to be eligible for federally funded assistance programs.

Several direct policies might serve as vehicles for the conditional implementation of indirect policies. These include subsidies, education and training programs, technical assistance, and planning grants. In each case the approach is the same: State and local participation in a direct Federal program is conditioned on implementation of certain policies at the State and local level. Failure to do so renders the jurisdiction ineligible for Federal funds.

Available conditional programs are related to the various institutional problems listed in table 51. On the whole, each of these indirect or conditional programs implemented at the State or local level affects a larger number of institutional problems than do the direct Federal options. This is because the main arenas for creating and resolving institutional problems in resource recovery are State and local governments.

It should be noted that none of the conditional policies is likely to reduce the technical or economic uncertainty of resource recovery. Rather, such policies act largely to remove specific institutional impediments to them. Even if all the local obstructions were to be removed, resource recovery might still not be economic or technically feasible in some areas.

Planning grants for State and local solid waste management provide the most convenient inducement to State and local governments to overcome the difficulties posed by multi jurisdictional organization for resource recovery. If administered through the States to local governments, such Federal funds can provide a double incentive for action beyond direct Federal control.

At the local/regional level, planning grants can work in two ways. First, most of the Nation today is served by multi jurisdictional regional planning agencies required by a host of Federal programs such as the OMB A-95 review procedure or the HUD "701" planning grant program. These agencies, which are often on the lookout for sources of funds, provide a potential constituency for participation in federally funded planning programs. Second, in the absence of regional agency involvement, the availability of planning funds may stimulate one community to become the advocate for multi jurisdictional planning; a course that might otherwise have been unaffordable.

RCRA strongly emphasizes regional planning in State-designated regions as a means to encourage resource recovery implementation. As noted in table 51, this approach is directed at overcoming a number of problems, including jurisdictional overlap and fragmentation, cost-sharing among communities, mixed private and public responsibilities for waste management, and facility siting problems. Each of these problems is exacerbated under the large-scale, regionalized approach to centralized resource recovery.

However, as discussed in chapter 5, in the last few years emphasis on the regionalized approach has declined as interest has grown in small-scale resource recovery systems featuring heat recovery. Thus, the need has also decreased for a regionalized planning and management approach to overcome the institutional barriers to regional systems. Furthermore, it now appears just as reasonable to select such regions on administrative and political/jurisdictional bases as on the basis of optimum technical and economic design of large-scale systems.

Findings on Overcoming Institutional Barriers to Resource Recovery

Institutions play key roles in the development and implementation of resource recovery. They are especially important in establishing or removing barriers to the emergence of centralized resource recovery as a new, uncertain and, therefore, risky technology for disposing of MSW. Many such institutional barriers are permanent features of society, so ways must be found to offset, rather than to remove them.

This chapter has discussed 17 types of institutional problems, in four classes, and has suggested three kinds of approaches to their solution.

The four classes of problems are: information problems, jurisdictional problems, implementation problems, and marketing problems. In general, three broad approaches are available to the Federal Government to address them: direct Federal action, Federal incentives to reduce risk and uncertainty, and Federal inducements to State and local governments. OTA has not attempted to rank the seriousness of these problems or the relative effectiveness of various approaches to their solution. All of the problems are important, and a mix of approaches is required to resolve enough of them to give resource recovery an opportunity to progress.

Each party to a resource recovery effort quite naturally tries to minimize the risks he faces, yet such risk avoidance has a price for all the parties involved. Finding ways to share the risks that derive from the technical and economic uncertainties of resource recovery is a major source of its institutional problems. Carefully designed Federal subsidy programs, among other approaches, can help overcome the risk barrier confronted by private entrepreneurs or public agencies in introducing new resource recovery technologies. Such a use of subsidies is conceptually different from their use to make projects appear economically feasible when they otherwise would not be. The first use of subsidy for resource recovery is clearly justified, the second less so.

A basic strategy of RCRA is to induce States to institute regionalized planning for solid waste management. This approach makes sense if large-scale regionalized resource recovery offers great economic advantages through economies of scale in processing wastes and selling recovered energy. In view of both recent trends toward small-scale systems and of the difficulty of marketing large amounts of recovered energy, especially to electric utilities, the importance of regional planning for disposal of ordinary MSW has lessened.

References

1. Wisconsin State Law, Chapter 305, Laws of 1973.
2. Thompson v. County *of Blue* Earth, 233 N.W. 2d 770 (Minn. 1975).
3. *Glenwillow Landfill* Inc. et *al.* v. City *of* Akron *et al.* (U.S. District Court, Northeastern District of Ohio, Eastern Division docket no. C78-65a). Oral argument is scheduled for May 1979.
4. "Note, Constitutional Law—Commerce Clause: Local Discrimination in Environmental Protection Regulation, " vol. 55, *North Carolina Law* Review, 461-473, March 1977.
5. City *of* Philadelphia v. *New* Jersey, 437 U.S. 617 (1978).
6. Occupational Safety and Health Act of 1970 5(a) (l), 29 U.S.C. 654(a)(1) (1970).
7. O'Hare, Michael, "Not on My Block You Don't—Facility Siting and the Strategic Importance of Composition, " *Public* Policy, vol. XXV, no. 4, fall 1977, pp. 407-458.
8. Gordian Associates, Overcoming Institutional Barriers to *Solid* Waste Utilization as an Energy Source. Final Report to the U.S. Department of Energy, report HCP/L-50172-01, November 1977.
9. Electric Power Research Institute and Edison Electric Institute, Invited Papers: Conference on Utilization *of Refuse* Derived *Fuels* by Electric Utilities, San Diego, Calif., Nov. 16-18, 1977.
10. U.S. Environmental Protection Agency, "Handbook for the Technical Assistance Panel Program. " This document was issued as an Environmental Protection Agency memorandum to its regional offices, Jan. 1, 1978.
11. Feller, Irwin, and Donald Menzel, *Diffusion of* Innovations in Municipal Governments; *Final* Report to the *National* Science Foundation, Grant DA-44350, June 1976. Available from NTIS as PB-257-069/AS.
12. "Memorandum of Understanding Between the United States Environmental Protection Agency and the United States Department of Energy on Energy Recovery From Municipal Solid Waste, " signed for EPA on Mar. 21, 1979.
13. Willey, C. R., Chief, Technical Services, Maryland Environmental Service, personal communication, Jan. 26, 1978.
14. 44 F.R. 3274-3285 (Jan. 16, 1976).
15. Office of Management and Budget, A-95 —Evaluation Review and Coordination *of* Federal and Federally Assisted Programs and Projects, Jan. 13, 1976.
16. 1954 HUD Comprehensive Planning Assistance Program amended in 1974 under Public Law 93-383.

Chapter8

Economic Policy, Waste Generation, and Recycling

Contents

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Economic Policy, Waste Generation, and Recycling

Background

Issues and Scope

As noted in the introductory chapter, economic forces strongly influence the flow of materials through our society from resource extraction to waste disposal. This chapter examines how existing or proposed Government economic policies affect these forces. It also examines the effectiveness of such policies in reducing the rate at which wastes are generated or increasing the rate at which they are recycled. The specific policy instruments examined are:

- product disposal charge,
- financial incentives to industrial users of recycled materials,
- severance tax on virgin materials,
- percentage depletion allowance for minerals, and
- capital gains treatment of income from standing timber.

The analysis of the options in this chapter, which reviews their effectiveness in accomplishing the goals of waste reduction and recycling, is both partial and preliminary. It is partial because these policies could have important implications beyond the scope of this study. These include impacts on recycling materials from other sources such as junked automobiles and industry, as well as impacts on the industries, workers, and other parties involved. It is preliminary in that it reports on a review of a small number of studies carried out by organizations other than OTA, which itself has not done independent quantitative analyses of the effectiveness, costs, or impacts of the existing or proposed policies. Furthermore, for reasons outlined in chapter 2 and elaborated below, it is extremely difficult to do good econometric analyses of the impacts of economic policies on scrap materials markets, and predictions of such impacts are necessarily quite uncertain. (Economic policies directed at stimulating the supply of recycled materials through source separation and centralized resource recovery are discussed in chapters 4 and 7.)

Related Studies

Two major efforts are currently underway in the executive branch to analyze and recommend economic policy initiatives for materials. The Cabinet-level, interagency Resource Conservation Committee (RCC), mandated by the 1976 Resource Conservation and Recovery Act, expects to report on the following seven areas;

1. subsidies for resource recovery,
2. litter taxes,
3. severance taxes,
4. percentage depletion allowances for extractive resources,
5. capital gains tax treatment of timber income,
6. freight regulations, and
7. deposit and bounty proposals.(l)

In a closely related effort, President Carter has directed executive branch agencies to carry out a Domestic Policy Review of Nonfuel Minerals Policy under the chairmanship of the Secretary of the Interior and the Presidential Science Advisor.(2) Economic policies are expected to be a major focus. Furthermore, the Secretary of the Treasury was directed by an amendment to the Internal Revenue Code to investigate and report on all provisions of the Internal Revenue Code that have an impact on recycling.(3) Their study has been delayed in the expectation of working through the Domestic Policy Review.(4)

Responses to Economic Policies Toward Materials

In this section, the responses of the materials system to economic policies are discussed as a basis for understanding the subsequent discussion of specific policy options. In addition, the most important side effects of these policies are presented.

For convenience, the responses of the materials system to economic policies are divided into primary responses, or effects on "materials flows, " and secondary responses, or "side effects. " The distinction rests on the intent of the policies, rather than the importance of their effects. In other words, since the goals of the policies are to reduce waste generation and increase recycling, these material flow responses are of primary concern. Any side effects of the policies could be equally or even more important but because they were unintended they are denoted as secondary responses.

Primary Responses: Materials Flows

Evaluation of the response of materials flows to economic policies is based on the principle that the rate of a material's consumption is influenced by its price, by the costs associated with its use, and by the prices and costs of using alternatives. (This is not to imply that prices and costs alone determine consumption. Institutional factors, for example, are also important. However, changes in consumption can be related quantitatively to small changes in costs and prices, at least in the short run.)

Five general responses might follow a change in the relative prices of materials. Suppose that there were a drop in the price of a recycled material relative to that of its virgin material counterpart. Furthermore, assume that all other prices and costs in the economy remain the same. The outcome might be any or all of the following:

1. Increased output from some industries that use the recycled material.
2. Substitution of the recycled material for the virgin material in certain applications.
3. Substitution of the recycled material for other materials in certain applications.
4. Substitution of the recycled material for other factors of production such as labor or capital in certain applications.
5. Development of new technologies or the emergence of new industries that use the recycled material.

In each of these cases, a different period of time would elapse before the response to the change in material price would take place. The above list is in order of increasing elapsed time. Responses that may take place over a period of several days to 1 or 2 years (the first three listed above), are said to occur in the "short run. " For example: (i) if the cost savings from using a recycled material are passed onto customers, an increase in output might occur within a few weeks because of a step-up in purchases; (ii) if existing equipment can be used, a recycled material can be substituted for a virgin material fairly quickly; and similarly, (iii) in the manufacture of certain products a recycled material can often be easily substituted for some other material. Responses that may take place over several months to several years (those of the fourth type) are said to occur in the "long run. " They usually involve making changes in capital equipment and in the work force in order to use more recycled material and less capital and labor. The fifth type of response to price change, technological innovation, usually occurs only in the "very long run. " It may take anywhere from 1 or 2 years up to 10 or more years to occur.

Analysts are best able to predict the responses of materials flows to price changes for the "short run. " In fact, responses of the first type are the basis for most of the theoretical models on which analytical studies are founded. For example, input-output analysis, a widely used methodology, is based on the assumptions that both the technologies and the ratios of capital, labor, and materials use are constant over time. It is only applicable to responses of the first type. Analyses of "short run" responses of the second and third types are difficult to carry out because the nature of the available data does not permit making statistically reliable estimates that fit the theoretical models. This is also true for long-run responses of the fourth type. In the case of studies of technological innovation in response to materials prices (very long-run responses of the fifth type) at present good theoretical models, on which studies could be based aren't even available. (5,6) As a consequence of these analytical shortcomings, most of the studies that have been done probably underestimate the changes in demand that would ultimately occur in response to price changes.

Perception is often unreliable for anticipating the response of material demand to changes in the prices of recycled materials. As has been previously discussed (see chapter z) the short-run demand for a secondary material actually increases at the same time as its price is increasing. This is a consequence of the higher prices that scrap dealers can charge when the short-run demand for all materials is high. The resulting variation in short-run scrap prices tends to be greater than the price changes that take place in the long run thus it acts to impede understanding long-run scrap market behavior.

The "availability" of materials also tends to influence their relative flows in the economy, since users have a preference for materials that are more available. Availability is related to price response, but is less well-defined. In the short run, a material is perceived to be "available" if the supply is highly responsive to price; that is, if purchasers can buy all they need at or slightly above the normal price. If this is not the case, or is perceived not to be the case, the material is said to be less available. Such short-run availability is closely related to the ability of productive capacity to be easily and quickly expanded. In the long run, availability is related to the potential for actual exhaustion of the resource base, or, in the case of scrap, to exhaustion of the available scrap inventory. Political factors also affect perceived availability. For example, the existence or possibility of new environmental restrictions, labor actions, or international market disruption may adversely affect availability.

Secondary Responses: Side Effects

This section presents an overview of the less specific, broader side effects or secondary responses that might be expected from changing economic policies toward materials use. For the purpose of this analysis, the five primary, or materials flow, responses discussed in the previous section as well as the materials system model in figure 2 (see page 30) should be kept in mind.

In this general discussion of side effects, it is assumed that a policy is adopted that has the effect of reducing the cost of using recycled materials relative to using virgin ones. Adopting such a policy would have side effects in the following areas.

Prices—Material prices may change by less than the changes in cost caused by economic policies. For example, producers may be unable to pass through all of the cost increases, or may be unwilling to pass through all of the cost decreases, a policy might create. For example, a new tax on a virgin material might raise its costs of production by a certain amount, X. But, if the demand for that material is elastic, only a portion of the cost increase could be passed on. Thus prices might increase by less than X.

Profits—In the price change example just discussed, an industry's profits would decrease if all of its cost increases could not be passed through. On the other hand, if the policy decreased costs and prices, profits might increase based on the increased sales. Similarly, a subsidy program, if not carefully designed, can provide extra profits on those sales that would have occurred without the subsidy. Such profits are commonly called windfall profits.

Government Revenues—If economic policies stimulate additional net economic activity, additional revenues may be generated that offset direct losses or augment direct gains. When new policies are adopted, the burden of taxation and the benefits of subsidies will shift among firms, industries, locations, points in time, and levels of government. The net effect of any particular policy on government revenues may be very difficult to predict and impossible to measure.

Government and Private Administrative Costs—The governmental and private sector administrative costs may be strongly dependent on the policy tool chosen. Taxation is a convenient way to administer incentives and disincentives, since they can piggyback on a preexisting system of recordkeeping, reporting, auditing, and enforcement. Using the tax system to implement incentives or disincentives may create the lowest private sector overhead costs. While taxation, as a policy, minimizes the need to make administrative decisions, it uses a system of considerable complexity. However, programs such as direct regulation, grants, loans, loan guarantees, and direct charges may require a more costly and cumbersome administrative structure. They may also be more prone to arbitrary decisions, error, court challenges, and bureaucratic inertia. But, incentive or disincentive policies implemented through the tax code are not subject to annual budget review, authorization, and appropriation. Therefore, they may be harder to amend or eliminate than are specific programs.

Foreign Competition-Policies designed to raise the costs of virgin materials might place domestic producers at a cost-price disadvantage compared with foreign suppliers of the same materials. Conversely, policies to reduce the costs of materials might open the United States to charges of unfair competition from foreign nations concerned that domestic policy might be used as a substitute for import duties.

Long-Run Materials and Energy Conservation—Depending on its nature and point of application, a policy may tend, over the long run, to increase or decrease the rate of extraction of virgin raw materials and the rate of consumption of energy. In the long run, any policy that reduces the apparent cost of recovering or using secondary materials and that does not affect the costs of virgin materials can be expected to increase the use of recycled materials and to have little effect on the use of virgin materials. In the short run, such a policy would tend to favor secondary materials. Over the longer run, however, it would make the use of all materials less expensive, on the average. Consequently, on balance, such a policy might even cause a small increase in the rates of extraction and ultimate disposal of materials. Conversely, policies that raise the relative costs and prices of virgin materials and that do not affect the costs and prices of secondary materials are likely to cause a reduction in the rates at which materials are extracted and ultimately disposed of. Such policies are also likely to encourage the recovery and recycling of materials from waste.

The energy required to process most virgin materials is greater than that required to process secondary materials. The exception is paper, for which energy use is sensitive to raw material choice and to whether energy from wood residues is counted as an energy input in virgin papermaking. The effect of each economic policy on energy consumption must be evaluated for the mix of virgin and recycled materials use that results.

Employment—The primary effect on employment of adopting policies to make secondary materials cheaper would be to stimulate employment both in recycling industries and in those that use materials. Policies to make virgin materials more expensive would increase employment in recycling industries and decrease it in those using virgin materials. The net impact on these and all other industries would have to be evaluated for each policy.

Available Policy Options

A large number of options are available for changing the relative costs and prices of virgin and secondary materials. There are three major considerations in selecting a policy: (i) the policy instrument, (ii) the point of application of the instrument, and (iii) the factor of production to which the instrument would apply. The ultimate selection is, of course, a political judgment reserved to Congress. (Analytic guidelines for evaluating policies are discussed at the end of chapter z.)

Table 52 lists feasible policy instruments, points of application, and factors of production that might be considered in designing economic policy to stimulate materials recycling and reduce waste. If the strategy is to stimulate materials recycling by making secondary materials cost relatively less than virgin materials, only certain combinations of instruments, points of application, and factors of production are reasonable. For example, an income tax credit for the use of recycled materials by material fabricators is a reasonable choice. However, not all instruments apply to all factors. For example, neither construction grants nor accelerated depreciation can be tied to materials or labor inputs. They only apply to capital investment. Finally, since recycling is usually more labor intensive than producing virgin materials, tax credits for wages paid to the formerly unemployed might stimulate recycling.

Table 52.—Options in the Design of Economic Policy Toward Materials

Feasible policy instruments
Severance tax
Excise tax
Ad valorem tax
Income tax credit
Income tax deduction
Special tax treatment of income
Construction grant
Loan guarantee
Low interest loan
Accelerated depreciation
Output material subsidies
ad valorem
per unit of output (recycling allowance)
Input material subsidies
ad valorem
per unit of input (recycling allowance)
Product charge
Disposal fee
Landfill tax
Litter tax
Deposit
Bounty
Feasible points of application
Virgin material extraction
Basic material processing
Material fabrication
Product fabrication
Wholesaling
Retailing
Waste discard and collect ion
Waste processor/ recycler
Secondary material processor
Ultimate waste disposal
Feasible factors of production
Virgin materials
Recycled materials
Capital
Labor
Energy

The Effectiveness of Selected Policy Options

The effectiveness of five policy options in achieving the goals of (i) enhanced recovery and recycling of materials, and (ii] reduced rate of disposal of municipal solid waste (MSW) is discussed in this section. Each policy and its rationale are described, followed by a review of the expected impact of the policy on costs or prices, and by estimates of its effectiveness. The following five options are considered in detail:

- The Product Charge—An excise tax levied on material goods proportional to their weight, volume, or other measure of disposal cost. The tax would be Ievied on material fabricators or related industries.

- Financial Incentives to Processors or Users of Recycled Materials—Direct grants or tax incentives to processors or users of recycled materials paid in proportion to the amount or value of recycled materials used, or in proportion to the cost of capital goods used for recycling.
- The Severance Tax—A tax on virgin materials levied at the point of mining or harvest in proportion to some measure of the amount or value extracted.
- The Percentage Depletion Allowance—Existing law allows for the deduction of a percentage of gross income from mining specified minerals from the income before taxes each year. In this analysis, modification or repeal is examined.
- Capital Gains Treatment of Income From Standing Timber—Existing law allows for taxing income from the sale of standing timber at rates appropriate to long-term capital gains, which are lower than rates for ordinary income. In this analysis modification or repeal of this tax preference is examined.

The product charge and user incentives are specifically designed to encourage recycling and discourage wasting materials. The severance tax has traditionally been used by States as a revenue measure, rather than as a recycling incentive. The percentage depletion allowance and capital gains treatment of income from standing timber are tax preferences designed to aid specific industries. Recycling was not originally a factor in establishing either of these policies.

The Product Charge

DESCRIPTION AND RATIONALE

The product charge is an excise tax or fee that would be levied on products destined to enter the waste stream after use. The rationale for this charge is that the user of a product should be aware of, and pay for, the cost of its proper disposal. Since product users do not pay directly for disposal, they have no incentive to recycle used products or to purchase goods that create less waste. The result is that users do not pay the full social costs of using products. The goal of the product charge is to include the cost of disposal in the original product price so that private costs will cover social costs. The intended outcomes are to stimulate recycling of used materials and to reduce the rate at which all materials are used.

A complete description of the product charge option requires specifying (i) the point of application, (ii) the amount and basis for the charge, (iii) the products to be covered, and (iv) the disposition of the revenues. The design of a product charge system would require considerable compromise between the ideal rationale and a working program. (See references 7 and 8 for extensive discussion of design issues.)

In principle, the disposal charge should be levied at the point of discard. In practice, however, solid waste management costs are paid as a flat fee or through general revenues. It is difficult to imagine how a system of direct charges proportional to the cost of disposal could be economically administered.

For maximum effectiveness, the charge should be applied either at the point of production or of purchase. However, this approach would require collecting it from a large number of producers or sellers. As a compromise the charge could be collected from bulk material producers. This would greatly reduce the number of collection points. It could, however, result in applying the charge to products not destined for waste, and could lead to charges on final products that are not related to the cost of their disposal.

The amount and basis for the charge is closely related to its point of application. Most proposals call for a charge that is proportional to product weight, as a measure of the cost of disposal. They also feature a separate charge by volume or by item for specific low-density items such as bottles and cans. The RCC staff analysis(7,8) suggests that such a charge structure would result in some products bearing charges that are grossly out of proportion to their costs of disposal.

The selection of products to be covered is an additional question. In principle, all goods destined for waste should bear the charge. Studies for the Environmental Protection Agency (EPA) have focused on paper and packaging because (i) most of these products end up as MSW, (ii) they make up a considerable fraction of all MSW, and (iii) they lend themselves both to analysis of the effectiveness and to administration of a charge program.

Some groups have argued that other manufactured products as well as food and yard wastes should also be covered. Many manufactured products, however, do not become solid waste, and charging for food and yard wastes would be difficult.

An important feature of the product charge proposal is that recycled materials would be exempt from the charge. The rationale for the exemption is that discarded products that are recycled do not create a disposal cost. In the same sense that the product charge compensates for direct disposal charges, an exemption to the product charge for recycled raw materials compensates for their not creating a disposal cost.

The final question is what to do with the charge revenues, which could amount to several billion dollars annually. They could be treated as (i) general Federal revenue, (ii) returned to States and cities under general revenue sharing, (iii) returned to localities to support solid waste recycling activities, or (iv) returned to individuals as a tax credit or as a reduction in the personal income tax rates. There is no compelling theoretical reason to favor any of these approaches. The most prevalent suggestion is to support local recycling activities such as source separation or centralized resource recovery. Many private firms engaged in waste management are concerned that such funds may be used to compete with them unfairly.

EFFECTIVENESS OF THE PRODUCT CHARGE

The product charge might have two principal impacts on materials use and recycling. The first is that consumers would buy fewer products containing materials that will become waste, since such products would be relatively more expensive. The second effect would be to cause producers to substitute some recycled materials for some virgin materials, assuming that the exemption feature is retained. This would be done because the relative price of virgin materials would be raised by the amount of the charge, say $26 to $30 Per ton of material. Furthermore, this increased demand for recycled materials by producers would serve to stimulate recycling activities at the local level. On balance, then, virgin material consumption would decline, recycling activity would increase, and the rate of ultimate waste disposal would decrease. The likely magnitude of these changes is addressed in the following discussion.

Two analyses of the effectiveness of a product charge were carried out by Research Triangle Institute (RTI) for EPA (9,10,11). Both studies were designed to test the short-run impacts of the product charge; one on all packaging materials and the other on all paper products. In the packaging study, the charge was assumed to be $0.05 per container for nonpaper rigid packages and $26 per ton for all other packaging. In the paper study, the charge was assumed to be a uniform $26 per ton. Each study estimated the decline in the rate of waste generation due to consumer price increases as well as the increase in the rate of recycling due to improved markets for secondary materials. The sum of these two effects is the overall decline in the rate of ultimate disposal of waste.

Very recently, a study of the effectiveness of the product charge on paper products was performed by Franklin Associates, Ltd. (FAL) and by the International Research and Technology Corporation (IRTC) for the American Paper Institute (API). It was assumed that a charge of $30 per ton would be phased-in over a 10-year period beginning in 1980. They estimated the effects of the charge on demand for paper, on recycling of paper, on solid waste generation, and on revenues in 1984, 1989, and 1999.(12)

The findings of the three studies are summarized in tables 53 and 54. RTI estimated that the product charge on packaging materials would have reduced the total MSW to be disposed of by 7.2 percent, and the charge on paper would have reduced MSW by 9.2 percent. Since these two categories overlap and the two studies were done somewhat differently, one cannot simply add these two results to get a more comprehensive estimate. However, they suggest that at least 10 percent, and probably more, of the waste stream would disappear as a result of the product charge. Since these are short-run analyses that cover only selected materials, the changes over a longer period of time could be considerably greater, but are more uncertain. These studies predict that the level of recycling from MSW might double if the product charge were adopted, in part because the current level is quite low.

In contrast, the study by FAL and IRTC found that a product charge on paper products would be much less effective than estimated by RTI, as shown in table 54. FAL's results suggest that the RTI estimates for a comprehensive product charge may be too high. Since the report for API was released shortly before the completion of this OTA study, it was not possible to make a careful comparison with the methods used by FAL/IRTC and RTI to explain the differences in their results.

Table 53.—Reductions in Postconsumer Solid Waste Resulting From a Product Charge on Packaging Materials in Base Year 1970
(thousand tons per year)

Packaging material	Waste reduction effect[a]	Resource recovery effect[b]	Total reduction
Paper and board	232	1,078	1,310
Plastics	40	0	40
Glass	216	4,078	4,294
Steel	238	2,532	2,770
Aluminum.	8	244	252
Total materials. . .	734	7,932	8,666
Percentage reduction in solid waste disposal[c]	0.60/0	6.60/0	7.20/.

SOURCE: RTI for EPA. (11)
[a]The estimated reduction in material waste generation resulting from reduction of consumer purchases due to increased product prices.
[b]the reduction in solid waste disposal attributable to increased material recycling.
[c]Based on estimated 120 million tons of municipal solid Waste disposed Of in 1970,

One important implication of the three studies is that the product charge would have only a small effect, apparently on the order of 0.5 to 3 percent, on consumer purchases of materials (the "waste reduction" effect). The major impact of the product charge would be to stimulate resource recovery and recycling in order to meet the new demand from manufacturers for recycled materials. Therefore, if it proves infeasible to exempt the use of recycled materials from the product charge, this charge would not be effective in reducing waste loads or in reducing the rate of virgin materials use.

D1SCUSS1ON OF THE PRODUCT CHARGE

Consumer Price and Income Effects—RTI analyzed other implications of the product charge proposals. These are discussed in their original reports (9, Io) as well as in the EPA Fourth Report to Congress.(n) They found that consumer product price increases might range from a fraction of 1 percent up to several percent. The charge on packaging had a greater effect on price than the charge on paper, especially for goods in rigid containers, which bear a much higher charge per ton. The weighted average consumer price increase for products affected by the packaging charge was estimated at 0.3 percent. The largest price increases due to the charge on paper were 1.4 percent for newspaper and 1.7 percent for paper napkins and facial tissues.

According to the RTI analysis, annual charges would range from $8 for families in the lowest income group to $59 for those in the highest income group, with an average around $30. Depending on how the charge revenues are distributed, the product charge could be designed to be regressive or progressive on balance.

Table 54.—Reductions in Total Postconsumer Solid Waste Resulting From a Product Charge on Paper Products

Study	Year of full charge phase-in	Waste reduction effect[a] (percent)	Resource recovery effect[b] (percent)	Reduction in MSW for disposal[c] (percent)
RTI for EPA(11) . .	1975	1.4	7.9	9.2
FAL and IRTC for API (12)	1989	0.84	0.9	1.3

[a]The estimated reduction materials waste generation resulting from reduction of consumer purchases due to increased product prices
[b]The reduction in solid waste disposal attribution to increased material recycling
[c]Based on estimated 1282 million tons of net waste disposed of in 1975 and 1758 million tons in 1989

Feasibility of the Exemption for Recovered Materials—As noted above, the exemption for charges on recycled materials is the key to successful operation of the product charge. Without it the product charge would reduce waste generation and the use of virgin materials by only a few percent, and would have little or no effect on recycling.

Identifying and certifying secondary materials that qualify as recycled postconsumer wastes is a major difficulty in administering this exemption. A charge system would provide an incentive for producers to try to include prompt and home scrap as well as virgin material in the exempt classification. Beyond the clear possibility of fraud, however, technical problems exist. These include: (i) defining postconsumer wastes, (ii) following them through the secondary materials processing system, (iii) deciding whether wastes recovered in processing postconsumer wastes are themselves postconsumer wastes or home scrap, and (iv) treating imports and exports. The administrative burden of dealing with these issues for both Government and the private sector may outweigh any gains due to the charge.

Compatibility of the Product Charge and Other Approaches—A product charge would stimulate and support resource recovery and recycling options such as source separation and centralized resource recovery by stimulating demand for the kinds of materials these programs would produce. Furthermore, some proposals call for distributing the product charge revenues in order to pay for local resource recovery and recycling activities. This could be a problem, since extra costs for source separation arise mainly in collection rather than in recycling activities. The impact of the product charge on the generation of waste, as noted in tables 53 and 54, is not large enough to significantly affect the economics of resource recovery or source separation.

The product charge would be compatible with beverage container deposit legislation. (See chapter 9.) Since refillable bottles would bear the product charge only at the point of manufacture, a charge, of say $0.05, would be spread out over the trip life of the bottle. Cans and nonreturnable bottles made from recycled materials would likewise have to bear only a fraction of the $0.05 product charge per fill, on average, since they could receive the postconsumer waste exemption. The average product charge revenues would continue to pay the disposal cost for discarded containers, while the mandatory deposit would provide the disincentive to litter and the incentive to return containers.

Financial Incentives to Industrial Users of Materials Recovered From MSW

DESCRIPTION, RATIONALE, AND ADMINISTRATIVE OPTIONS

A variety of financial incentives could be offered to processors and other users of materials to induce them to select recycled rather than virgin materials as production inputs. * The economic rationales for such incentives are that they offset the tax and other incentives given to producers of virgin raw materials, and that they help to overcome existing institutional barriers to recycling. These incentives could be in the form of investment tax credits, direct grants, low- interest loans, or loan guarantees. Users of recycled materials could also be given incentives to employ persons to work with recycled materials. Recycling incentives could be offered to recycling firms, scrap processors, scrap dealers, or product fabricators. The selection of a policy would be based on effectiveness, administrative feasibility, and costs as well as on economic principles.

The administrative difficulties of identifying and certifying eligible postconsumer waste materials, which were previously noted to cause problems for the product charge, also present problems for recycling incentives. Eligible materials could be most easily identified at the recycling firm level (separate collector or resource recovery operator). There are a number of such firms, however, many of which are very small. The administrative burden of certifying eligible materials for these firms could be high. There are fewer scrap processors or dealers. However, the problems of distinguishing postconsumer from other scrap are highest at this level. Directing the allowance at product fabricators would require a detailed manifest system to ensure its proper allocation to postconsumer recycled materials, which at this point might be indistinguishable from, and mixed with, other recycled and virgin materials. There appears to be no way to avoid the cost of administering recycling incentives. Even with voluntary compliance the private sector would have the expense of keeping track of recovered materials.

*In the closing days of the 95th congress, the Energy Tax Act (Public Law 95-618 Stat. 3174) was passed, It contains a provision for an additional 10-percent investment tax credit (for a total of 20 percent) for the purchase of equipment used to recycle ferrous (with certain exceptions) and nonferrous metals, textiles, paper, rubber, and other materials for energy conservation.

THE EFFECTIVENESS OF THE RECYCLING INCENTIVES

Resource Planning Associates (RPA), under contract to EPA, analyzed the effectiveness of five specific programs of incentives to users of materials recovered from MSW. They estimated the impact that each would have on the extent of recycling from MSW, if these incentives were implemented in 1975.

Table 55 shows RPA's results for incremental waste recycling over the lo-year period from 1975 to 1985 for each of the op tions, along with the cost of their implementation. It also shows the results for 1975, the first year of the model programs. An incentive option's effectiveness would depend on its level, but RPA did not analyze this dependence. As can be seen from table 55, the most effective of the five options over the 10-year period is the 30-percent purchase price subsidy. But it is also the most costly to the Government. On the other hand, the most cost-effective option, 5-year accelerated depreciation, has the smallest impact on recycling.

RPA considered some of the long-run shifts in industrial practices that the incentives would encourage. By comparing the 1- and lo-year cumulative effects, it can be seen how short-run (first year) analyses can underestimate the long-run (lo-year) impacts of such policies.

Table 56 shows OTA'S calculations of the impact of each of the five options on the amount of solid waste to be disposed of, based on the ratio of RPA's estimates of additional recycling to EPA's projections of solid waste disposal. In 1975, the programs would have reduced the solid waste to be disposed of by around 1 percent, increasing to around 2 percent in 1980, and to 3 percent in 1985. The most effective policy in reducing waste disposal is a subsidy of 30 percent of the purchase price paid to users of recycled materials (4.7-percent reduction in waste disposed of in 1985). (See table 56.)

The RPA study shows that user subsidies would reduce the total burden of solid waste

Table 55.— Effectiveness of Various Subsidies to Industrial Users of Materials Recovered From MSW

Policy option	Incremental waste recycling: 1975 (million tons)	1975 (percent increase)	10-year total (1976-86) (million tons)	10-year total (1976-86) (percent increase)	10-year cost -to Federal Government (billion dollars)	1 O-year cost-effectiveness ($/ton)
30 percent of purchase price	1.7	19	51	48	1.38	2700
$6 per ton of output.	1 2	13	32	30	0.84	2610
25-percent investment tax credit	1.1	13	32	30	0.35	1084
5-year accelerated depreciation. . . .	0.6	6	16	15	0.10	658
75-percent tax credit on interest cost.	1.3	14	37	35	0.81	21.90

SOURCE RPA (13)

Table 56.— Effectiveness of User Subsidies in Reducing the Amount of Solid Waste to be Disposed of

Policy	Percent reduction in sol id waste disposed of •: 1975	1980	1985
30 percent of purchase price	1.3	3.1	4.7
$6 per ton of output	0.9	2.0	2.9
25-percent Investment tax credit	0.9	2.0	2.9
5-year accelerated” depreciation	0.4	1.0	1,5
75-percent tax credit on interest cost.	1.0	2.3	*3.4*

“ Based on net solid waste disposal without subsidy of 128, 156, and 166 million tons per year in 1975, 1980, and 1985(14) and on Incremental recycling estimates from RPA(l 5)

to be disposed of by only 1.5 to 4.7 percent after 10 years. Such subsidies would be more successful in inducing additional recycling of materials from postconsumer wastes since they would cause a 15-to 48-percent increase over the recycling level projected in the absence of subsidies. Administering a subsidy program, to ensure that participants use subsidized capital equipment for the intended purpose or that subsidized materials are in fact recovered from postconsumer wastes, might be a significant problem.

The Severance Tax

DESCRIPTION AND RATIONALE

The severance tax is a tax on virgin materials levied at the point of extraction, mining, or harvest in proportion to the physical amount or economic value produced. Severance taxes have historically been imposed by States to generate revenues or to pay for environmental programs or land restoration. They have typically been levied as a percentage of net income or gross dollar sales, or based on a physical measure of production such as weight or volume. Table 57 shows typical State severance tax levies.

The severance tax can be viewed as a mechanism to offset the cost advantages other policies extend to virgin materials. These include tax preferences (percentage depletion, capital gains on timber income) and indirect subsidies (royalty-free use of public lands for minerals and timber, the inland waterway system, R&D funding, mapping and exploration programs). Programs that give virgin materials a cost advantage do so to accomplish social and political goals or as a spillover from other program objectives. Thus, the severance tax is an alternative to

Table 57.—Typical State Severance Taxes

State	Tax basis
Arkansas	15C per ton of bauxite mined
Idaho	2 percent of value of ores mined
Kentucky	4 percent of value of coal mined
Minnesota,	15 percent of value of taconites mined
Minnesota	15.5 percent of value of iron ore mined
Montana	30 percent of market value of coal mined

SOURCE (16)

the modification or elimination of such programs.

Another rationale for imposing this tax is to induce long-run resource conservation. It could be designed to correct resource prices for the bias against future generations that results when current decisionmakers discount the future.(17) Taxes on net income are more desirable if resource conservation is the goal, since severance taxes levied on gross sales or on the physical amount extracted encourage the waste of low-grade deposits when they are co-mingled with high-grade ones.

EFFECTIVENESS OF THE SEVERANCE TAX

Under the severance tax, recycling would be stimulated in response to higher relative prices of virgin materials. Unfortunately, no studies have been made of the impacts of a severance tax on the production of virgin materials or on recycling. Since such an analysis was not performed by OTA, no quantitative judgment can be made on its short-or long-run impacts. Clearly, a key determining factor would be the level of the tax relative to total production costs. If the severance tax were set at a few percent of production costs, it might have recycling impacts roughly equivalent to those of repeal of the percentage depletion allowance, which would also increase costs by a few percent (see below).

DISCUSSION OF THE SEVERANCE TAX

The severance tax would be easier to administer than either the product charge or user incentives because first, the number of primary materials producers is considerably smaller than the. number of users: second, since the tax would be applied to virgin material producers there would not be a problem in distinguishing among virgin materials and various kinds of scrap materials; third, there would be no need to be concerned with an exemption for recycled materials; and fourth, firms already report the production and/or sales information required to administer the tax.

The severance tax would apply to all materials, not only to those destined for MSW. For paper and glass, this difference is not great, since about two-thirds of their production becomes MSW. (See chapter 2.) However, only one-fourth of aluminum, one-eighth of ferrous metal, and one-twentieth of other nonferrous metals produced are used in products that become MSW. Thus, this tax would help recycled materials compete with all virgin materials, not just those destined for MSW. On the other hand, if recycling from MSW is the only objective of this tax, the cost to the virgin materials industries could be excessive. Furthermore, unless the severance tax were also applied to imports, a cost advantage would be given to foreign producers of virgin ores and primary metals.

Percentage Depletion Allowance [Modification or Repeal)

DESCRIPTION AND RATIONALE

Existing law allows for deducting various percentages of gross income from mining specified minerals from the income before taxes each year. The effect of this special provision of the tax code is to reduce the tax cost of producing virgin hardrock minerals compared with what it would be if producers had to adjust taxable income on some less favorable basis. The percentage depletion allowance provision has been the subject of a long and sometimes bitter debate. (Its history can be reviewed in a number of sources (16-24).) Supporters of the percentage depletion allowance argue that it is a necessary subsidy to the domestic minerals industries, especially in the face of competition from imported materials. Opponents argue that it is inefficient, because it stimulates overuse of scarce resources and exacerbates some associated environmental problems, and that it is inequitable because competing industries, especially the secondary materials industries, do not receive an equivalent subsidy. It is beyond the scope of this analysis to attempt to resolve these arguments.

From the perspective of resource recovery, recycling, and reduced waste disposal, the key question is whether the economic advantage that percentage depletion gives virgin materials over secondary materials is sufficient to be a major barrier to increasing recycling and reducing waste. Such economic advantage could take the form of lower relative prices for virgin materials than would otherwise be the case. Virgin materials could receive a further advantage if the percentage depletion provision encourages vertical integration of industries from extraction through material fabrication. This would create a barrier to free competition between primary and secondary materials if vertically integrated firms were to set artificially low transfer prices for their own virgin raw materials even though scrap material prices might be lower than virgin-based raw material prices on the open market.

EFFECTIVENESS OF REPEAL OF PERCENTAGE DEPLETION

Since percentage depletion gives an advantage to virgin materials, it is of interest to know whether its modification or repeal would stimulate significant resource recovery, recycling, and waste reduction.

Two major studies, one for EPA by the Environmental Law Institute (ELI)(16) and one for the Bureau of Mines by the JACA Corporation, have recently examined the impact of Federal taxes on the competition between virgin materials and the kinds of secondary materials that are recoverable from MSW.

Both studies estimated the impact of percentage depletion on the cost of producing virgin materials. Table 58 summarizes the results of these analyses. Percentage depletion was found to reduce the cost of producing aluminum by about 1 percent and of steel by about 2 percent. However, the repeal of the depletion allowance would not necessarily lead to price rises equivalent to these percentages. Firms might not be able to pass through all increased costs due to market resistance and to competition from imports. Thus, price increases of less than 1 percent for aluminum and 2 percent for steel would be expected.

Table 58.—impact of the Percentage Depletion Allowance on the Costs of Production of Primary Metals

Material	Year	cost reduction • (percent)	Source
Aluminum ingot.	1973	0.6	JACA (18)
	1974	0.8	JACA (18)
	1975	0.7	JACA (18)
Aluminum.	1973-75	2.2 (maximum)	ELI (16)
Pig iron. ...	1973	1,7	JACA (18)
	1974	2.1	JACA (18)
	1975	2.1	JACA (18)
Steel	1973-75	3.0 (maximum)	ELI (16)
Steel	1973-75	2.0 (likely)	ELI (16)

“ For JACA cost reduction is lax savings as a percent of market price for alumium and of transfer price for pig iron For ELI cost reduction is the per cent shift in industry out put at any price i e the shift in the supply curve

Anderson and Spiegelman of ELI estimated the effects of the repeal of the percentage depletion allowance on the recycling of waste materials due only to the shift in relative prices of primary and secondary materials. They estimated short-run increases in recycling from all sources of only 0.42 percent for obsolete steel scrap and 1.7 percent for old scrap aluminum. In the unlikely event that all of the short-run increases in recycling would be from materials in MSW, percentage increases in recycling from MSW would be somewhat greater than the short-run estimates. They point out that the long-run investment related impacts of repeaI of percentage depletion on materials recycling may be larger than these estimates, and estimated a

6.4-percent increase in recycling of obsolete steel scrap in the long run.

None of the studies reviewed by OTA examined whether percentage depletion has stimulated vertical integration in the materials industries or whether such integration is a significant barrier to recycling. Further analysis of this topic would be desirable.

DISCUSSION OF REPEAL OF PERCENTAGE DEPLETION

The ultimate impact of repeal of the percentage depletion allowance on materials recycling and on reduction of MSW is still uncertain. The ELI and JACA studies suggest that the direct effect of cost and price changes on recycling would be small. However, further analysis of this action would be necessary before predictions could be made with confidence. The impact of percentage depletion on the structure of the materials industries and thus on the nature of the competition between virgin and recycled materials should be investigated. Careful consideration would also need to be given to the impact of repeal of the percentage depletion allowance on costs, profits, performance, employment, and foreign competition in the affected domestic metals industries such as steel, aluminum, and copper. Issues of effectiveness aside, the percentage depletion allowance does appear to give an inequitable advantage to primary materials producers.

Capital Gains Treatment of Income From Standing Timber

DESCRIPTION AND RATIONALE

Existing law allows for taxing of income from the sale of standing timber at rates appropriate to long-term capital gains. These are lower than rates for ordinary income. This provision of the tax code is said to reduce the costs and therefore the price of virgin paper and wood products. It also has the effect of stimulating greater investment in timber production, compared with what it might be without this advantage.

The history and operation of the special tax treatment of timber income along with analyses of arguments in support and in opposition, are presented in an extensive review article by Sunley.(25) Both Sunley and Anderson and Spiegelman(16) note that preferential tax treatment for timber income is not based on economic theory, but on a long history of attempts to provide special tax treatment to various industry sectors, and on a series of compromises with those who have tried to eliminate such treatment.

EFFECTIVENESS OF MODIFICATION OF CAPITAL GAINS TREATMENT OF STANDING TIMBER INCOME

From the point of view of waste generation and materials recycling, the question of whether capital gains treatment of timber income has stimulated overproduction of timber or inhibited recycling of wastepaper should be raised. In a recent analysis, Anderson and Spiegelman estimated that woodpulp market prices are reduced by a maximum of 4.2 percent by the capital gains provision, but that the actual value may lie closer to 1.0 percent than to 4.2 percent. Using several economic models, they estimated that the capital gains treatment of timber income depresses wastepaper recycling by between 0.04 percent and 1.5 percent. A repeal of the tax provision would increase recycling by the same percentages. Accordingly, there would be a short-run increase in recycling of 0.04 percent that would further increase over a longer period of time to 1.5 percent as new plant investment decisions were made. These results suggest that repeal of the capital gains treatment of timber income would be ineffective in increasing postconsumer wastepaper recycling.

Regardless of its effects on the level of recycling, however, the current treatment for tax purposes of income from standing timber gives an advantage to producers of paper from virgin wood not enjoyed by recyclers. Equity considerations would call for removal of this inequity.

Findings on Economic Policy Options

This chapter has been concerned with the potential effectiveness five economic policies would have in stimulating recycling and reducing the rate of MSW disposal. By drawing on previously published literature, it has been possible to present preliminary and partial data for some impacts of certain policies. These findings are summarized in table 59. The entries in the table represent generalizations from the more detailed information presented in the chapter. No entries are shown for the severance tax. However, if it were limited to rates similar to those in current State programs, its effects would probably be on the order of only a few percent.

From equity, economic efficiency, and administrative perspectives, removing existing tax preferences for virgin materials is preferable to establishing new ones for recycled materials. From the perspectives of resource recovery, recycling, and reduced generation of waste, the key question, however, is the effectiveness of various proposals in stimulating recycling and decreasing the waste disposal burden.

Of the five policies considered, the product charge and the recycling allowance appear to be the most effective for these purposes if they could be made to work. However, the effectiveness of the product charge would depend on the successful implementation of the exemption for recycled materials, and the administrative problems of the exemption may be so great as to render the charge concept unworkable. The recycling allowance faces similar administrative problems.

Table 59 suggests that repeal of the percentage depletion allowance on hardrock minerals or repeal of the capital gains treatment of timber income would increase recycling very little. Furthermore, these actions are not expected to significantly reduce the generation of waste, although quantitative estimates of this impact have not been made. Nevertheless, these tax provisions do treat

Table 59.—Generalized Summary of a Preliminary Assessment of the Impacts of Selected Economic Policies on Waste Disposal and Recycling

Policy	Decrease in disposal of MSW (percent)	Increase in materials recycling from MSW (percent)
Product charge	7 to 10+	100 or more
Recycling allowance*.	1.3 to 4.7	19 to 48
Severance tax	?	7
Repeal of percentage depletion allowance.	?	0.4 to 1.7
Repeal of capital gains treatment of standing timber income	?	0.04 to 0.7

“Financial Incentives to users of recycled materials

secondary materials unfairly in their competition with primary materials.

However, indirect effects on recycling may be larger than indicated by table 59. Additional analyses are needed to explore more fully the implications of these provisions of the tax code for the nature of the competition between primary and secondary materials and for the competition between domestic and foreign producers.

OTA has not systematically assessed the side effects of the five policies examined in such important areas as prices, profits, Government revenues, administrative costs, employment, foreign competition, or long-run materials and energy conservation. Each of these need to be analyzed indepth to get a complete picture of the outcomes of such policies.

Each of’ the five options considered would be supportive of or compatible with resource recovery programs and beverage container deposit legislation, because each would strengthen the market for recycled materials.

Other economic policy options might be considered for adjusting the short- or long-run competition among primary and secondary materials. The five discussed here, while the most widely considered, do not exhaust the possibilities outlined in table 52.

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Only a small number of studies of the response of materials flows to economic policies have been published. Further research and analysis are needed to help clarify this important area of resources policy. Studies are needed on the influence of economic policy on plant investment decisions, including plant location, and on vertical integration in the materials industries to determine whether these effects serve to inhibit the use of recycled materials in the long run.

Finally, this chapter has examined a number of Federal policy options, each of which would have only a limited effect on resource recovery and recycling. Adopting several such policies together might serve to create a climate in which activities would grow beyond those predicted by the economic models.

References

1. Committee Findings and *Staff* Papers on *National* Beverage Container Deposits. Second Report of the Resource Conservation Committee, January 1978.
2. Presidential Proclamation, Administration of Jimmy Carter, 1977. *Nonfuel* Minerals Policy: Announcement *of* Cabinet-Level Interagency *Study*, Dec. 12, 1977.
3. Public Law 94-568 (90 Stat. 2697) amending the Internal Revenue Code of 1954.
4. Personal communication, Seymour Fiekowsky, U.S. Department of the Treasury.
5. Gander, James P., "The Relationship of Technological Change and the Demand for and Supply of Raw Materials, " Department of Economics, University of Utah, report to the National Science Foundation under grant number RDA 74-20198 A04, 1976.
6. Greenberg, Edward, Christopher T. Hill, and David J. Newburger, "Regulation, Market Prices, and Process Innovation: The Case of the Ammonia Industry, " Westview Press, Boulder, Colo., 1979.
7. "Rationale for National Solid Waste Disposal Charge Legislation," Resource Conservation Committee Staff Background Paper No. 8, Apr. 17, 1978.
8. "Solid Waste Disposal Charge Design Issues," Resource Conservation Committee Staff Background Paper No. 9, Apr. 17, 1978.
9. Miedema, A. K., T. H. Bingham, and J. Daber, "Preliminary Analysis of a Product Charge on Major Components of Post-Consumer Solid Wastes," report by Research Triangle Institute for EPA, June 7, 1976.
10. Miedema, A. K., et al., "The Case for Virgin Material Charges: A Theoretical and Empirical Evaluation in the Paper Industry, " report by Research Triangle Institute for EPA, January 1976.
11. Environmental Protection Agency, Fourth Report to Congress on Resource Recovery and Waste Reduction, EPA Report SW-600, 1977, pp. 88-99.
12. Franklin Associates, Ltd. and International Research and Technology Corporation, *Solid* Waste Management and the paper Industry, prepared for the Solid Waste Council of the Paper Industry, March 1979, p. v-3.
13. Research Planning Associates, "A Study of Federal Subsidies to Stimulate Resource Recovery, " report for EPA, 1974, pp. 17-46. Available from NTIS as PB-239-736.
14. Environmental Protection Agency, op. cit., p. 20.
15. Resource Planning Associates, op. cit., p. 95a.
16. Anderson, Robert C. and Richard D. Spiegelman, "Impact of the Federal Tax Code on Resource Recovery," report to EPA by the Environmental Law Institute, December 1976. Report EPA-600/5-76-009. Available from NTIS as PB-264 886.
17. Page, R. Talbot, Conservation and Economic *Efficiency*, Johns Hopkins Univ. Press, Baltimore, Md., 1977.
18. Commins, James A., et al., "Barriers to the Use of Secondary Metals, " report to the U.S. Bureau of Mines by JACA Corp., Fort Washington, Pa., August 1977.
19. Anderson, R. C., A. S. Miller, and R. D. Spiegelman, "U.S. Federal Tax Policy: The Evaluation of Percentage Depletion for Minerals, " Resources Policy, 3, 165-178, September 1977.
20. Tannenwald, Robert, "Analysis and Evaluation of Arguments For and Against Percentage Depletion, " Congressional Research Service report 78-68E, Mar. 11, 1978.
21. "Copper, Percentage Depletion and The Public Interest," prepared by AMAX Inc. and 10 other copper companies, undated, mimeo (1978).
22. Letter to W. M. Blumenthal, Secretary of the Treasury, from J. Allen Overton, Jr., President, American Mining Congress,

Aug. 23, 1977. Publically available from AMC.
23. Material Needs and the Environment *Today* and Tomorrow. Final Report of the National Commission on Materials Policy, June 1973, pp. 4D-14 to 4d-17.
24. Government and the Nation's Resources. Report of the National Commission on Supplies and Shortages, December 1976, pp. 160-166.
25. Sunley, Emil M., Jr., "The Federal Tax Subsidy of the Timber Industry," The *Economics of* Federal Subsidy Programs, U.S. Congress Joint Economic Committee, 1972, pp. 317-342.

Chapter 9

Beverage Container Deposit Legislation

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Beverage Container Deposit Legislation

Introduction

Objectives and Questions Addressed

Legislation that mandates a minimum, refundable deposit for all containers used in the sale of carbonated malt beverages (beer) and soft drinks is one policy option for reducing the rate of solid waste generation. In its simplest form such legislation requires that all parties in the distribution train from brewers and bottlers to retailers charge a minimum deposit, say 5 cents per container, which must be refunded on presentation of an empty equivalent container. Such legislation neither mandates the use of refillable containers nor bans the use of nonreturnable ones. * The intent of such proposals, however, is that containers be used that are either refillable on cleaning or recyclable into new containers or other goods. If enacted, such legislation would require that the voluntary deposit system employed by industry for many years for refillable bottles be extended to all types of beverage containers.

The objectives of mandatory beverage container deposit legislation (BCDL) are:

1. To reduce the number of beverage containers that become littered.
2. To reduce the amount of natural resources, both materials and energy, devoted to beverage delivery.
3. To reduce the amount of beverage container materials that enter the solid waste stream.
4. To establish a public symbol of materials conservation.

Mandatory deposits have been considered for such other goods as automobiles, tires, electrical machinery, consumer durables, and food packaging; some of which could be reused and others of which would require some level of remanufacture.** This study, however, is limited to beverage container deposit proposals for several reasons: they are now on the public agenda, a body of analytical work has been done on them, and the congressional request for this study asked for investigation of this option. The major points addressed in this chapter are:

1. Options for addressing the beverage container issue.
2. The uncertainties in assessing the effectiveness and impacts of BCDL.
3. The history and background of the existing beverage container system.
4. The effectiveness of BCDL in achieving its goals.
5. The positive and negative side effects of BCDL.

*Containers designed to be used for beverage delivery only one time are denoted by a variety of adjectives including nonreturnable: nonrefillable: one-way: single-service: throwaway: no-deposit/no-return; recyclable; disposable: and convenience. In this study, the term ‘‘nonreturnable” is used to describe such containers. Containers designed to be collected, cleaned, and refilled are called “refillable.” Currently, all refillable beverage containers in commercial use are made of glass. “Recyclable” is used to denote containers whose materials can be reprocessed to make new containers or other useful objects.

**Figure 2 (see chapter 2) shows how reuse and remanufacture approaches (loops 3 and 4) differ from recycling and resource recovery options. Remanufacturing is one of the subjects covered in an OTA report on materials conservation.(1)

6. Current trends that may influence the future of the beverage delivery system, with or without BCDL.

Rationales For and Against Government Action

The economic rationale for mandatory beverage container deposits is that certain costs of the production, use, and disposal of beverage containers are not paid by the participants in those actions but by society at large. This happens because the market system does not provide incentives to the participants to pay for all of the costs they create. (In other words, there is a case of what analysts call "market failure.") These include litter costs (esthetic loss; pickup costs; injuries to people, livestock, and wildlife; and damage to vehicles and other machinery), pollution costs (some of the air and water pollution from producing materials and manufacturing containers), and solid waste management costs (collection, disposal, and landfill pollution). Both equity and economic efficiency might be served by Government action to ensure that the participants pay these costs, providing that such Government action does not create even greater problems.

Seven States and a number of local governments have passed beverage container laws. The provisions of the existing laws are detailed in appendix D for the States of Connecticut, Delaware, Iowa, Maine, Michigan, Oregon, and Vermont. Several other States have defeated beverage container deposit proposals in recent years, including four that have done so by popular referendum: Alaska, Colorado, Massachusetts, and Nebraska. Virginia has passed a law prohibiting local ordinances that require beverage container deposits, with an exception for ordinances previously on the books.

Proponents of BCDL argue that market forces, which exclude external costs, have led to adoption of a beverage container system that is wasteful of raw materials and energy and that provides little incentive to consumers to avoid littering or to reduce solid waste. As a result, industry produces billions of beverage containers each year that from a technical point of view are nearly but not quite reusable. Deposit laws would provide incentives to consumers to avoid littering and to avoid adding containers to the solid waste stream. At the same time they would provide an incentive to producers to consume less energy and materials by using containers that, while only marginally different from nonreturnable ones, can be collected and refilled a number of times. To BCDL proponents, the demise of the disposable beverage container, which has become symbolic of a wasteful society, would symbolize a new spirit of conservation.

Opponents of mandatory deposit laws argue that the current beverage delivery system is the most economical one and that consumers have chosen it by expressing their preferences in the marketplace. They argue that imposition of a deposit law would be costly for industry, would disrupt existing employment patterns causing a loss of skilled jobs in can and bottle production, and would place a hidden cost on consumers in the form of additional time and storage space requirements. They doubt that a deposit system would actually "work," in the sense that the container return rates and refillable bottle market shares required to achieve the intended benefits would not be reached if producers, sellers, and consumers do not cooperate. (Market share is defined as the percent by volume of packaged beverages sold in each container type.) Opponents also argue that beverage delivery costs would increase and would be passed on in the form of higher retail prices for beverages or as higher prices for other consumer products sold with beverages.

Sources of Uncertainty in BCDL

In the last several years, BCDL proposals have been discussed and analyzed extensively. A great deal of effort has been expended in making detailed projections of the effectiveness and impacts of deposits. * Yet little agreement appears to have been reached on the basic "technical facts, " let alone on the policy questions. There are a number of possible explanations.

First, the economic and political stakes in the deposit controversy are high. The direct economic costs of BCDL to industry, labor, and certain communities are perceived to be large. Similarly, there are serious political concerns about litter, solid waste, and materials and energy conservation. For these reasons, interested parties have worked hard to support their positions.

Second, proposals to require beverage container deposits are comparatively simple to understand and their effects are relatively easy to foresee. Studies have been carried out by private organizations, Government agencies, academic groups, and environmental organizations. Thus, a body of literature of diverse quality has grown up around the issue. Prior to this study, however, no critical review and evaluation of this literature has been made.

Third, certain key aspects of the response of the beverage container system to imposition of mandatory deposits cannot be accurately predicted either from current understanding of the functioning of markets or by extrapolation from the historical record. Return rates and market shares for various container types are difficult to predict along with such other factors as: the volume of sales and the prices of beverages, the additional costs to industry, the nature of technological innovation in the future, and the costs or benefits to consumers of changes in the convenience aspects of the beverage delivery system.

Fourth, various proposals for beverage container laws have been discussed at the Federal, State, and local levels. Some are for mandatory deposits, some for litter control, and others would ban nonreturnable containers altogether. Mandatory deposit proposals differ with respect to timing, range of container materials covered, treatment of nonrecovered deposits, and container design. Each of these proposals can lead to significant differences in their expected effectiveness and impacts. The specific proposal examined in this report is the one discussed by the Resource Conservation Committee (RCC) in its second report to Congress.(2) This choice does not represent an endorsement of the RCC model, but provides a basis for the analysis. (The RCC model is very similar to the Hatfield-Jeffords proposal. See appendix B.)

Fifth, many attempts have been made to forecast what the effects of a national law might be based on the experiences of four States that currently have functioning mandatory deposit laws: Oregon, Vermont, Michigan, and Maine. Widely different claims have been made in each case. Experience with these State laws has proven inadequate for judging a nationwide system for several reasons: there are no good baseline data available for any State on the situation existing before deposits were required, thus precluding valid comparisons; in the cases of Oregon and Vermont, producers have been able to influence the outcomes by withdrawing from the market or manipulating prices (many Vermont consumers can easily purchase beverages in neighboring States without deposit laws); and finally, many of the effects of these laws are felt outside the States, especially on out-of-State container, material, and beverage producers and labor. These limitations will apply to the performance of any deposit requirement imposed on a small area such as a State or a military facility.

Sixth, a number of emerging trends in the beverage industry may invalidate most of the analytic work that has been done on BCDL. These include the rapid acceptance of the plastic soft drink container and the recent

In appendix two widely quoted major studies are critically compared. One is a study of a ban on cans and nonreturnable bottles by the Wharton School of Business, University of Pennsylvania, for the U.S. Brewers Association and the other of a mandatory deposit system by the Research Triangle Institute for the Federal Energy Administration.

Federal Trade Commission (FTC) decision outlawing territorial franchises for soft drinks in nonreturnable containers.

It is unlikely that these uncertainties in the performance and impacts of a nationwide beverage container law will be resolved by further analysis. Wherever possible in this chapter, uncertainties in the analysis are emphasized, conflicting views are noted, and their implications for the conclusions examined. Attention is focused on the pivotal roles played by return rates and container market shares as determinants of the effectiveness and impacts of deposit legislation.

Beverage Container Policy Options

Description of Options

The current discussion nationwide centers on the mandatory deposit approach. However, table 60 lists other approaches, some of which have been adopted in certain States and localities. Each option, if adopted, would have different degrees of effectiveness in achieving the goals of beverage container legislation and different impacts. The options are described and discussed in this section.

NO ACTION

No action means that no change will be made in current Federal policy toward beverage containers. Such policy is limited to the health, safety, environmental, fair labeling, antitrust, and alcoholic beverage regulations. No other existing policies directly affect container choice and design. If no Federal action is taken continued beverage container control activity can be expected at the State and local levels.

PROHIBITION OF NONRETURNABLE BEVERAGE CONTAINERS

A ban on the sale in interstate commerce of beverages in nonreturnable containers would cause nonreturnables to disappear from the marketplace (presuming adequate enforcement). * It would, however, only achieve its maximum effectiveness if bottlers and brewers were to establish a voluntary deposit system for all refillables. Otherwise, a ban would fail to provide any new incentive for consumers to return containers or to cease littering.

A ban would have a number of disadvantages. First, it would eliminate the option of consumers to purchase beverages in lightweight, nonbreakable cans and plastic bottles since only glass containers are currently refillable. The desirability of cans and plastic bottles is likely to continue for carrying beverages long distances, for consuming beverages in areas in which broken glass would be a major hazard (recreation areas, around small children), or by those who prefer consuming beverages in cans.

A ban might also inhibit the development of new container systems, types, materials, or sizes that might otherwise evolve. For example, a nonrefillable but recyclable container might be developed from a new material and be less resource-intensive and less expensive than any currently available refillable or non-

Table 60.—Selected Federal Options for Achieving the Goals of Beverage Container Control

1. No action
2. Prohibitions (bans) on interstate sale of nonreturnable containers
3. Expanded litter control efforts including education, pick-up, and litter law enforcement
4. Litter taxes on containers
5. Mandatory labeling of container portion of beverage price
6. Excise taxes on nonreturnable containers
7. Policies to lower the prices of secondary materials relative to those of virgin materials (product disposal charge, recycling subsidy, reduction or elimination of percentage depletion allowance, severance tax)
8. Solid waste management options such as resource recovery or source separation
9. Prohibitions on particular materials of container construction
10. Prohibitions on particular container design features

SOURCE Off Ice of Technology Assessment

*Th. analysis of restrictive packaging legislation b the Wharton School for USBA is a study of this kind of prohibition and response, (See appendix D for an analysis of this study,) returnable container. Under a ban, the development of such new technology might not proceed.

Banning nonreturnables would be the most disruptive of current distribution patterns, and would require the largest additional industry investment of any of the policy options. It would also be likely to reduce beverage sales for the reasons of consumer preferences mentioned above. Therefore, it might be the most costly option for industry, workers, and consumers.

Finally, the prohibition of an economic activity is a very powerful tool of Government policy. It is best reserved for circumstances in which no other acceptable options exist. In this situation, the deposit option might work equally well if not better than a ban.

EXPANDED LITTER CONTROL

Expanded efforts both to control the generation of litter and to collect it have been widely proposed as an alternative to BCDL by Keep America Beautiful, Inc. (KAB), an organization in which representatives of the container and beverage industries play a central role,(3) KAB developed and promotes the Clean Community System, an approach to litter control that strongly depends on modifying community norms to reduce or eliminate sources of litter. It can be tailored to the particular litter problems of each community. KAB reports (5) that litter accumulations under the Clean Community System are typically reduced by 20 to 80 percent as measured photometrically. * No data are given on the effects of the system on beverage container litter.

Litter control programs can include more frequent and effective pick-ups and better law enforcement, as well as behavioral approaches. However, people usually litter items that are of little or no value to them, Direct litter control programs provide only a weak economic incentive to overcome this factor in littering and no incentive for pickup by scavengers. They also do nothing to reduce the solid waste disposal problem or to conserve material and energy. Litter laws are difficult to enforce, since constant surveillance is required. In addition, higher fines are probably counterproductive; they may lead to dismissal of charges and/or lax enforcement. The approach adopted by California has been to reduce litter fines to $10 per violation in the expectation that citations will become more frequent and enforcement more effective.(6)

*See the discussion on p. 192 for a description of this technique.

LITTER TAXES ON CONTAINERS AND OTHER PRODUCTS

A tax on litterable products, including containers, has been proposed as a State-level alternative to deposit legislation. It has been adopted by several States, notably Washington and California. Washington State's Model Litter Control Act was passed by its legislature in 1971 and ratified by its voters in the general election of November 7, 1972.(7) The Act places a gross receipts tax of $150 per $1 million gross sales on manufacturers, wholesalers, and retailers of any product ". . . including packages, wrappings, and containers thereof . . . reasonably related to the litter problem . . ." The proceeds of the tax are used for educating the public about the provisions of the Act, for purchasing litter receptacles, for funding a full-time litter patrol to enforce the litter law, and for paying for litter pickup.

The California Litter Control, Recycling, and Resource Recovery Act of 1977 was designed to provide funds for a variety of functions associated with these activities. Funds were to be raised by a surcharge of $0.25 per ton on certain MSW disposal facilities as well as by a system of taxes on retailers, wholesalers, and manufacturers.(6) In February 1979, the parts of the Act that imposed a tax on retailers were repealed and the remaining taxes were to be imposed gradually.(8)

If such a tax were placed on both refillable and nonreturnable beverage containers, a very small incentive would be provided to induce beverage producers, retailers, and consumers to favor refillables over nonreturnables. Thus, it would have little effect on the nonlitter goals of a deposit law because it would cause little change in container market shares and return rates.

MANDATORY CONTAINER PRICE LABELING

It has been argued that consumers are either unwilling or unable to decide whether beverages are cheaper in refillables or in nonreturnables under the existing voluntary system. This is presumably due to the large number of brands and container types and sizes; also because it is not always clear whether posted prices include the deposit. One approach would be to require labeling the deposit portion of the posted price so that consumers might more readily be able to determine the best buy. To the extent that price labeling would enhance the purchase of refillables, it might achieve the goals of a deposit law.

EXCISE TAXES ON NONRETURNABLES

This option, which would levy an excise tax of several cents per nonreturnable container, would make refillable containers relatively less costly than nonreturnables. By so doing it would serve to make beverages in refillables more attractive to both producers and consumers, and it might induce producers voluntarily to establish a comprehensive deposit system to ensure returns. Such a tax would have to be large to be effective—say 5 cents per container. Its administration would require making a potentially difficult determination of the types of containers that are indeed nonreturnable.

POLICIES TO RAISE THE RELATIVE PRICES OF VIRGIN MATERIALS

Broad policies such as the product disposal charge, recycling subsidies, severance taxes, and reduction of existing percentage depletion allowances for minerals would all serve to make virgin raw materials and new products made from them slightly more expensive in comparison with recycled materials and reusable products, than they are now. Each would raise the price of nonreturnables as compared with refillables. Such policies also provide direct or indirect incentives to recycling. This might stimulate an increase in voluntary deposit requirements as well as in the recovery of discarded containers. Some reduction in litter generation would be expected. However, the price changes and the effects of these policies on container use would be relatively small. (See chapter 8.)

SOLID WASTE MANAGEMENT OPTIONS

Both centralized resource recovery and separate collection (source separation) of municipal solid waste (MSW) have been offered as alternatives to beverage container deposit proposals. These approaches have a wider range of goals and impacts as discussed in chapters 4 through 7. Neither option contributes to solving the litter problem, which each might worsen by stimulating a further decline in the use of refillables.

The impacts of BCDL on the economics of separate collection and centralized resource recovery are examined in chapters 4 and 6.

PROHIBITIONS ON PARTICULAR CONTAINER CONSTRUCTION MATERIALS

Another option is a Federal ban on the interstate sale of beverage containers made of particular materials such as aluminum, steel, or plastic. Such a ban has many of the undesirable aspects of a ban on nonreturnables discussed above. It runs the risk of prohibiting the most desirable types of containers, at least in some regions. Furthermore, a ban on metal or plastic containers would not affect nonreturnable glass and would stimulate its use. In one case, a local tax ordinance directed specifically at plastic packaging was found to be unreasonably discriminatory by a State court.(9) It is reasonable that the Federal Government should exert control over the materials used in beverage containers in order to protect public health, as discussed later in this chapter.

PROHIBITIONS ON PARTICULAR CONTAINER DESIGN FEATURES

Proponents of deposit legislation often argue for a ban both on aluminum pull-tops on beverage cans and on plastic six-pack holders. Neither pull-tops nor plastic carriers have a significant impact on the use of energy and materials or on the generation of solid waste. Due to their small size, however, pull-tops are more likely to be littered and remain as permanent litter than are metal cans, and are hazardous to people and wildlife. Laws in 12 States currently prohibit the sale of cans with pull-tops. The beverage industries are rapidly replacing them with cans having non-removable opening devices.

The major problems associated with plastic six-pack holders are esthetic blight and the hazards they pose to wildlife. The use of the plastic six-pack holder would probably be reduced if a deposit law were passed, since it cannot easily be used as a holder for returning empty cans.

Design Considerations for the Beverage Container Deposit Option

INTRODUCTION AND CRITERIA

Since BCDL would be complex legislation, a number of design details need to be examined. Some of the details could be specified in legislation while decisions about others might be delegated to the department or agency responsible for administering a law. The choice among design options would have considerable influence on the effectiveness of a deposit law and would affect the extent and incidence of the impacts of a law on various parties. In this section, the design decisions are identified, and considerations with respect to their resolution are discussed. A variety of sources were used including the report on beverage container deposits by the staff of the interagency Resource Conservation Committee [11) and a study done by the University of Michigan.

Economic efficiency, fairness, effectiveness, and minimum Government involvement are useful criteria for decisions on design issues. Since correction of market failure is the rationale for a deposit system, a deposit law should not introduce additional market inefficiencies. In particular, the selection of specific materials, containers, or beverages to be covered by a deposit law is likely to create a system that is inefficient, ineffective, and unfair. One feature of the deposit approach is that it is nearly self-administering by the market, so that it requires very little administrative involvement by the Government.

NATURE OF THE DEPOSIT

Deposit or Refund.—BCDL could require either mandatory deposits or mandatory refunds for containers. Under the deposit approach the law would mandate that someone (see below) charge a deposit for the use of his containers and that the containers would remain his property. The parties further along the distribution chain would act as his agents in collecting and disbursing deposit funds. Under the refund approach ownership of the container would be assumed by each party that buys it and its contents. The law would require that parties up the distribution chain (retailer, wholesaler, producer) buy back (pay a refund for) containers of a type used or sold by them. The difference between a deposit and a refund maybe unimportant to the consumer, but it could influence the tax treatment of monies involved, product liability, and proprietary rights in container designs. Under a refund system, the “deposit” monies are treated the same for tax purposes as any other income or expense of doing business. No special levies would be needed for unrefunded deposits.

Amount of Deposit.—A minimum deposit of 5 cents is at the heart of all proposals. This sum apparently reflects current industry practice, since no analyses have been made of the quantitative response of the beverage delivery system to other deposit values. Generally, the deposit should be large enough both to stimulate a high return rate and so that retained deposits can help offset the producers' costs of running a deposit system. However, it should not be so high that returns are discouraged. If the sum of the deposit and the cost of handling refillables exceeded the price of a new container, producers and distributors would discourage returns.

One or Two-Tiered System.—BCDL might mandate minimum deposits only for nonreturnables, while allowing traditional market forces to establish the deposit amount for refillables. However, this approach could cause technical arguments over whether a particular type of container is, in fact, refillable. Furthermore, such an approach would have the effect of favoring glass and discriminating against metal and plastic.

Adjustment of Deposit Amount.—The amount of the deposit would need to be adjusted to account for inflation. This could be done by legislation, by administrative decision, or according to a formula indexed to a measure of inflation, such as the consumer price index.

Minimum or Maximum Deposit. --Producers might be given the option to set higher deposits to cover their costs or to cover large containers. No public purpose would appear to be served by setting a maximum deposit.

Establish Certified Containers.—The Oregon law sets a lower deposit (z cents) on containers that the State certifies as standard and usable by a variety of producers. Standard containers would be easier to use and return for both producers and consumers. For this reason, they would probably emerge as an economic response under a uniform deposit law. There appears to be no need for a lower deposit or a governmental certification apparatus.

Beverages Covered.—Most proposals cover carbonated beverages (soft drinks and beer) in individual, closed servings. It is reasonable to expect a marketing shift toward noncarbonated beverages in vending machines and small retail stores in response to a national deposit law on carbonated beverage. This shift could result in an undesirable circumvention of the goals of BCDL, and may ultimately lead to proposals to include other beverages. Other beverages that might be included are noncarbonated drinks, juices, milk, water, mineral water, iced tea, wine, and spirits. * Before such additions were made, it would be necessary to analyze their effectiveness, costs, and impacts.

Materials Covered.— Some proposals would establish different deposits for containers made of different materials. This approach would appear to be discriminatory and might inhibit innovation in the development of potentially desirable new containers such as refillable plastic bottles.

Require a Deposit on Secondary Packaging.—Under a container deposit system producers would be likely to adopt more durable and versatile secondary packaging (cartons, cases, and the like) to facilitate returns, obviating the need for a deposit system for secondary packaging. Such a requirement might be much harder to administer than the container deposit requirement.

ADMINISTRATION OF THE DEPOSIT SYSTEM

Which Agency and What Functions.—Most proposals call for administration of the deposit system by the Environmental Protection Agency (EPA). It might also be administered, in whole or in part, by the Department of Commerce (DOC), the Internal Revenue Service (IRS), the Federal Trade Commission (FTC), or a new agency. Federal agency functions could include education and technical assistance, adjustment of the amount of the deposit, decisions to require deposits on additional types of beverages, or enforcement of compliance with the deposit requirement. However, it should be noted that once established BCDL uses market forces, and would require little Government participation.

Enforcement Requirements.—A deposit law must include sanctions for the failure of producers, distributors, or retailers to charge

*Federal law currently prohibits commercial reuse of liquor bottles. (CFR-173.43, sec. 27 of the Internal Revenue Code.)

or refund deposits as required by law. It introduces an element of mandatory purchase into ordinary business transactions, since used containers must be repurchased. The refusal to do so would create a problem for consumers and small firms. A method of speedy, cheap enforcement is needed, therefore. Such enforcement should be discretionary, however, to avoid creating undue short-term cash-flow hardship for distributors or retailers subject to a heavy influx of returns, One can imagine a "reverse boycott" in which a retailer or distributor is intentionally subjected to a very heavy flow of returned containers as a form of economic harrassment. Similarly, retailers in vacation areas may experience an excess of returns over sales from travelers.

Point of Origin of Deposits.—The deposit could originate at several points: container manufacturer, bottler/brewer, distributor/wholesaler, or retailer. The logical points of origin for a national deposit are the bottlers and brewers, since the objective of the legislation is to create an incentive for these companies to reuse returned containers. It is the bottlers and brewers that have sufficient market power through economies of scale, advertising, franchising, and market shares to frustrate the functioning of the deposit system. There is little purpose in requiring distributor/wholesalers or retailers to recover used containers if bottlers and brewers refuse to take them back for reuse, so the participation of the latter must be assured. However, if deposits originate at the brewer/bottler, there is no need to require containers to be physically transferred back to particular bottlers or brewers, since these firms may be able to work out more cost-effective approaches based on the establishment of a private market for the exchange of used containers.

Treatment of Imports.—Special provision may be required for imported beverages. In this case the importer rather than the brewer or bottler might originate the deposit. Importers are unlikely to return containers to the country of origin, but in order to remain price competitive with U.S. brands they might adopt a standard container such as the 12-ounce beer bottle, which would retain high value under a deposit system. At any rate, fairness to domestic producers requires that imports be included in the deposit system.

Establishment of Redemption Centers.—Some proposals include Government operated or licensed redemption centers for returned containers, and some would excuse retailers from accepting returns if a redemption center is nearby. Oregon's law contains such a provision, but no centers have been established. Centers may arise independently if they can serve an economic purpose, Thus there is no evident need for a special provision for them. Likewise, a policy to excuse retailers near a redemption center would require an extensive administrative apparatus to make and police determinations of compliance.

Treatment of Retained Deposits.—Not all deposits would be refunded since not all containers would be returned. These retained deposits would accrue in the first instance to the originator of the deposit, i.e., to the bottier/brewer. It has been proposed by some that these deposits should be treated as a windfall profit to be taxed away by a special tax. Others have proposed treating them as ordinary business income, subject to income tax—an approach compatible with a mandatory refund rather than a deposit system. To the degree that beverage markets are competitive, it would be likely that any "excess" profit would be shared with distributors, retailers, and consumers through reduced prices, In this event, a tax on retained deposits would make beverage prices rise under a deposit system, rather than let potential cost savings drive prices down. On balance, a special tax on retained deposits appears to be unnecessary and to be undesirable from a consumer point of view.

Compensation of Retailers.—Some proposals would earmark a portion of the deposit, say 1 cent, for compensating retailers for extra effort in handling returned containers.

Some State laws have such a provision, If markets are competitive, such a provision is unnecessary and undesirable. If need be, retailers can set their prices to recover any extra costs. Furthermore, a l-cent rebate would reduce a retailer's incentive to control the costs of recovery.

IMPLEMENTATION OF THE DEPOSIT

Time-Phasing of Deposit Implementation.—A decision must be made on the time between the date of passage into law and the date of implementation, as well as about whether a law would take effect uniformly on a particular date or be phased-in gradually. Generally, time delays of 2 to 3 years are proposed in order to allow for orderly adjustment by the industry to the deposit requirement. While longer delays might allow for a smoother transition, in fact, during the transition, each producer, wholesaler, and retailer has an economic incentive to avoid instituting a deposit earlier than his competitors. As a result, all may put off necessary adjustments to the last minute. Thus, a shorter rather than a longer period may be just as effective.

Preemption of State and Local Laws.—A Federal law might preempt local laws, grandfather existing laws, or allow for optional higher State or local deposit requirements. Higher State or local deposits might be desirable to induce better local performance or as a testing ground for possible changes in Federal policy. However, State and local governments should probably be discouraged from retaining or establishing container design requirements that might unnecessarily frustrate the efficient functioning of a nationwide deposit system by forcing producers to serve disparate markets.

Special Impact Assistance Programs.—Depending on program design, time-phasing, and system response (sales, market shares, recycle/return rates), BCDL may harm particular sectors of labor, manufacturing, or retail trade. Proposals have been discussed for special aid, which includes financial assistance, job retraining, or technical assistance. Another view is that existing programs for economic assistance are adequate for this purpose. Special assistance programs could become a windfall for those who would otherwise successfully make the transition under existing assistance programs or with no assistance at all. Administrative costs could be high. See pp. 215 & 220 for discussions of impact assistance for industry and labor.

Dimensions and History of Beverage Container Use

Containers, Resources, and Waste

In 1977, the United States produced nearly 73 billion carbonated beverage containers, manufactured from 8.6 million tons of materials, as shown in table 61. These containers contributed over 8 million tons to the municipal solid waste stream; about 6 percent of the total. Beverage containers make up nearly half of all the glass and aluminum in MSW.

Table 61 shows that the production of containers for beverages is a large part of the production of rigid containers for all purposes. Over 95 percent of all aluminum cans, over so percent of all glass bottles, and over 42 percent of all steel cans are used for beer and soft drinks. While plastic beverage containers currently hold a small part of the beverage container market their market share is growing extremely rapidly for soft drinks in larger sizes (24 to 64 ounces].

The energy required in all phases of the beverage container delivery system in 1975 has been estimated to be between 358 and 465 trillion Btu, excluding the energy required to produce the beverage itself. (See table 60.) This energy represents between 0.5 and 0.66 percent of the total U.S. energy consumption for 1975, and is equivalent to 1.2 to 1.5 percent of the total U.S. energy consumption for industrial purposes.

The historically increasing demand for beverage containers reflects: (i) growth in per capita demand for beer and soft drinks, (ii)

Table 61 .—Beverage Container Production, Materials, and Wastes in 1977

Container type	Production (bill ion)[a]	Beverage containers as a percent by number of all containers of this material[a]	Gross material used (million tons)[b]	Gross material used as a percent by weight of domestic consumption	Beverage containers in solid waste (million tons)[b]	Beverage containers as a per cent by weight of solid waste[d]	Beverage containers as a percent by weight of each material in solid waste[e]
Glass bottle							
Refillable	1.9[f]	. . . .	. . . .	. . . .	. . . .		. . . .
Nonreturnable	19.3[f]	. . . .	. . . .	. . . .	. . . .		. . . .
Total glass .	21 .2f	50.4?40	6.52	30.0%	6.52	4.80/.	48.00/.
Aluminum can . . .	25.8	95.6%	0.64	12.070	0.47	0.35%	48.00/.
Steel can							
Three piece[g] . .	18.3	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Two piece	7.3	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Total steel. .	25.6	42.4%	1.39	1 so/o	1.26-	0.90/o	1 2.00/0
Plastic.	0.3[h]	3.3%	0.01	0.07%	0.01	0.007%	0.2%
Total beverage containers	72.9	. . . .	8.56	. . . .	8.26	6.1 '/o	. . . .

[a]Industry data (15, 16)
[b]OTA estimates from table 67
[c]OTA estimates based on table 67, on domestic consumption of aluminum and steel from US Bureau of Mines(1 7), and on OTA estimates for total glass consumption of 22 million tons and plastic consumption of 141 million tons in 1977
[d]Based on assumed 135 million tons of net muncipal solid waste disposed of in 1977
[e]Based on table 3 composition data for 1975, the latest year available
[f]1976 data from Glass Packaging Institute (15)
[g]Usually made with aluminum lid
[h]OTA estimate

shifts in the kinds and sizes of containers used as beverage packages, and (iii) growth in the population. The first two factors are undoubtedly connected, in the sense that availability of convenience-oriented packaging facilitates increased per capita consumption, while increased per capita demand facilitates entry of new package concepts into the marketplace. This section examines trends in per capita beverage demand and in container use patterns, some of the forces that underlie those trends, and the history of the resulting demand for containers.

Beer and Soft Drink Consumption

The growth in total consumption of beer and soft drinks is shown in figure 6. Figure 7 shows the growth in per capita consumption for each beverage.

In a study for the Federal Energy Administration, Research Triangle Institute (RTI) [20) found that historical per capita consumption of beer over the period 1947-73 could be explained statistically by three independent variables: average personal disposable income, the price of beer relative to other goods, and the proportion of the population between ages 20 and 34. They found that consumption of soft drinks was strongly related to average personal disposable income and to the proportion of the population between ages 10 and 29. The relative price of soft drinks was not an important factor in explaining consumption. *

In a study for the U.S. Brewers Association (USBA), Weinberg argues that per capita beer consumption began to increase dramatically after 1958 due to the increased use of "convenience' (nonreturnable) packaging from 1947 through 1970.(21) He further con-

*price elasticities of demand were – 0.6 for beer and – 0.13 (not statistically significant) for soft drinks. Disposable income elasticities were + 0.25 for beer and + 1.47 for soft drinks. Population group elasticities of demand were + 0.70 for beer and + 0.79 for soft drinks,

Figure 6.—Annual Beverage Consumption in the United States

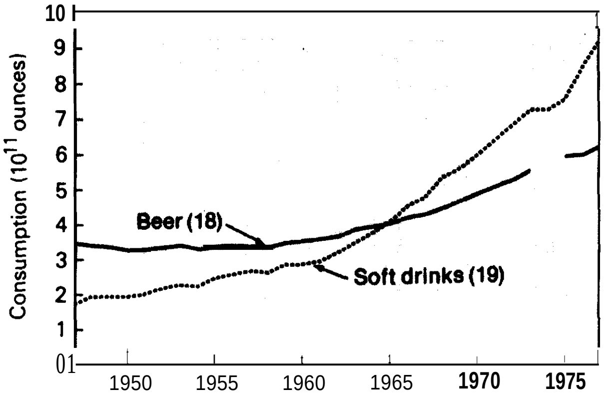
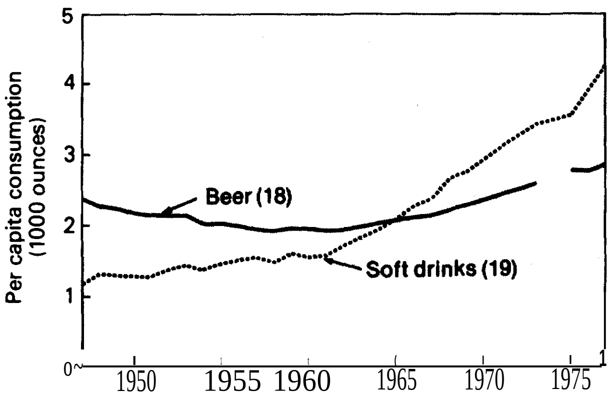


Figure 7.—Annual Per Capita Beverage Consumption in the United States



eludes that ". . . the increase in malt beverage consumption after 1958 cannot be explained in terms of shift in population (age distribution)." He also argues against a consistent influence of disposable income on beer consumption, because per capita consumption decreased linearly with income from 1947 to 1958 and then reversed to increase linearly from 1959 to 1970. These conclusions contrast with the RTI findings that the proportion of population between ages 20 and 34, along with disposable income and beer price relative to other commodities, are very significant in determining per capita beer consumption.

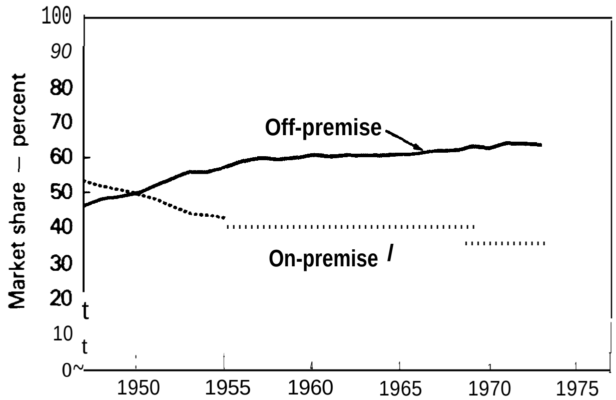
The differences between the conclusions reached by RTI and by Weinberg on the determinants of per capita beer consumption are important because they lead to different predictions about the response of beer consumption to a deposit system. If beer consumption has been stimulated by the availability of nonreturnable containers (the Weinberg argument), then a deposit law that would make nonreturnable packaging more expensive would tend to depress beverage consumption. If, however, beer consumption is determined by disposable income, price, and demographics (the RTI finding), then a deposit law would affect beer consumption only by having a direct effect on beverage prices and not by any effect on convenience. Both arguments are plausible; the RTI finding, however, is based on a statistical test while the Weinberg argument is more intuitive. In any case, statistical time series arguments of the sort made by RTI allow for the possibility that some other untested independent variable might also "explain" the observations. Weinberg's argument, on the other hand, tends to confound total beverage consumption with market shares by package type, both of which may be responding to untested external economic and social variables.

Over the years, the Nation has experienced a shift in the location of beverage consumption. Figure 8 shows the shift for beer from the on-premise market (taverns, restaurants) to the off-premise market (in the home or in recreational settings). Change in the places of consumption has stimulated change in container demand. Thus there has been a shift from bulk packaging to individual serving-sized packages for beer, while the trend for soft drinks has been toward bulk packaging. (See figure 9.) This difference may reflect the rapid growth of both "fast food" and institutional settings, where soft drinks are sold in open cups from bulk packages.

Historical Shifts in Container Types, Materials, and Market Shares

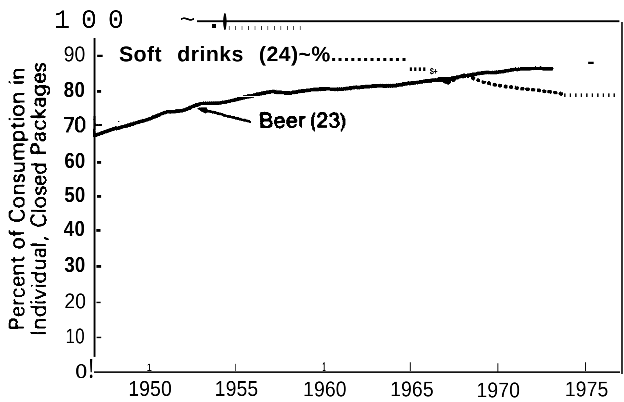
Until the 1930's all packaged beer and soft drinks were marketed in refillable glass bot-

Figure 8.—The Dual Beer Market



SOURCE (20)

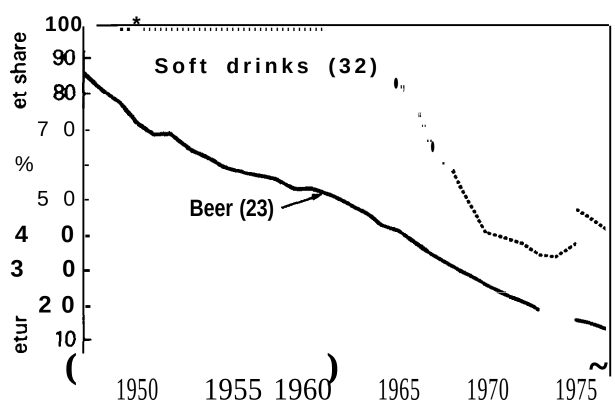
Figure 9.—Packaged Beverage Market Shares



ties. * The soldered steel can made its debut in the beer market in 1935.(26) Steel cans entered the soft drink market in 1953.(27) The all-aluminum can first appeared in the general market in 1964,(28) although it had been used by Coors a few years earlier. The bimetallic aluminum-lid/steel-body/pull-top can began to be used in 1962.(29) Nonreturnable beer bottles were used for overseas delivery during World War II but their substantial domestic use for beer did not begin until 1959.(30) Having been introduced in 1948,(31) nonreturnable glass bottles played a small role in the soft drink market for some years. They were given considerable impetus by the twist-off cap, nonreturnable bottle introduced in part to help glass container companies retain their market shares in the face of inroads by metal cans. More recently, container manufacturers have developed new beverage container systems such as the two-piece steel can; various plastic bottles (polyacrylonitrile, ** polyester, and polystyrene foam-over-glass); and a laminated container made of wood fiber and plastic, None of these are refillable.

Five container systems now serve the packaged beer and soft drink markets: refillable glass bottles, nonreturnable glass bottles, all-aluminum cans, bimetallic steel body/aluminum lid cans and polyester plastic bottles. Figure 10 shows the rapid decline in market share of refillable containers during the last

Figure IO.—Beverage Market Shares in Returnable Containers

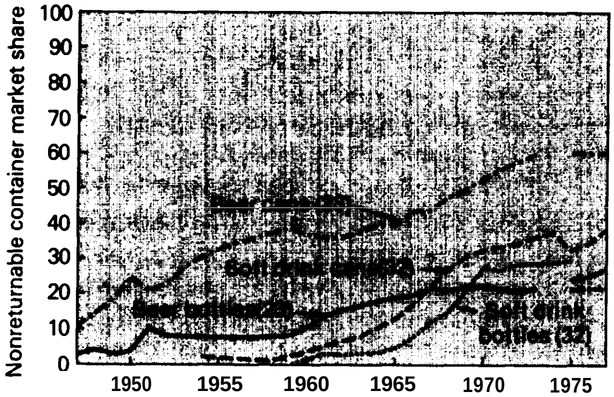


*In the early years of the packaged beer and soft drink industries, refillable bottles were a highly valued property of the brewers and bottlers. The American Bottlers' Protective Association, an organization of bottlers and brewers formed in 1889, proposed passage of a Federal Bottle Law to protect their property rights in bottles that were then being diverted with a loss of several million dollars per year. The proposed law passed the House of Representatives but not the Senate in 1896. In 1899, the Association abandoned the Federal approach in favor of seeking individual State controls. In 1901, the Association endorsed a proposal for industry adoption of bottle deposits. However, adoption of a deposit system took many years.(25)

**See page 229 for a discussion of the recent FDA ban on the use of acrylonitrile-based plastics for beverage containers.

20 years. Figure II shows the growth in market share of nonreturnable containers.*

Figure 11.—Beverage Market Shares in Nonreturnable Containers



A number of factors have stimulated the shift from refillable to nonreturnable beverage containers. Some have acted on producers, some on distributors and retailers, and some on consumers. They include:

Factors Affecting Producers.—

1. The lower weight of cans and nonreturnable glass and plastic bottles, with lower transportation costs, lower labor costs, and less worker injury than with refillables.
2. The absence of collection and back-haul costs for nonreturnables.
3. The increase in the optimum size of regions serviceable from a single bottler or brewer as a result of reduced transport costs due both to the lower weights of nonreturnables and to the improved highway transportation system.
4. The increase in industry concentration and a focus on nationwide marketing.
5. Reduced investment in inventories of bottles and secondary packaging.
6. The more rapid filling machinery for cans than for bottles.
7. The lower cost of the capital equipment used for filling nonreturnables.
8. The decline in refillable container return rates.
9. Short-term price promotions are more economical as a marketing tool with nonreturnables, since there is no need to make a longer term investment in bottle inventory.

Factors Affecting Distributors and Retailers.—

1. Shifts to self-service, high-volume supermarkets as beverage sales points.
2. Container inventory costs are lower with nonreturnables, particularly in the case of modern, low-inventory, supermarkets.
3. Reduced space and labor costs in handling nonreturnables.
4. The decline of the local tavern as a neighborhood center.

Factors Affecting Consumers.—

1. The increased acceptance of beer at home.
2. The growth in outdoor eating and recreational activities.
3. The growth in the demand for nonreturnables in response to the increased value of the time required to make returns, including the increased value of the time of housewives who are in the labor force.
4. The unavailability of refillables at many places where beverages are sold.
5. The unavailability of beer in convenient refillable packages such as six-packs.

The shift to nonreturnable containers has apparently facilitated the centralization of bottling facilities; the expansion of the marketing ranges of formerly regional brands, especially for beer; and a tendency toward a smaller number of larger companies. Nonreturnables supported these changes because it

*The National Soft Drink Association estimates and reports market shares in two ways: by survey of bottlers and by computation from container shipments. In recent years, the survey of bottlers has given larger market shares for refillables and lower shares for nonreturnables than have the calculations based on container shipments. For the present study, the survey of market shares is used to calculate materials used in 1977, NSDA statistics do not yet account for the market share of plastic containers, which, although currently small, is growing rapidly.

wasn't necessary to pay for the costs of returning bottles and because the lighter nonreturnables are cheaper to ship. Furthermore, larger bottling plants have lower average production costs than the smaller plants they replaced. The concentration and centralization of the beverage industries has also been facilitated by the economies of scale in the nationwide marketing of beverages on radio and television.

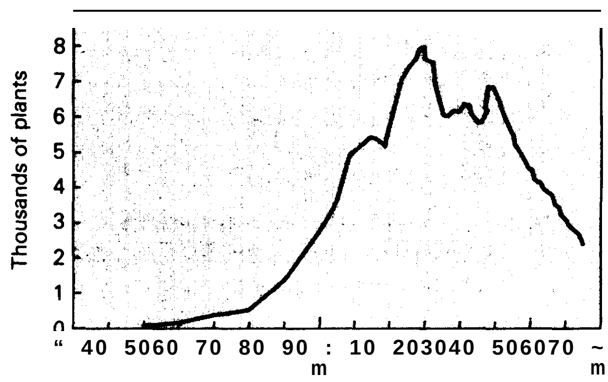
The centralization of production facilities was accompanied by a steep decline in the number of local soft drink bottlers and in the numbers of brewers and brands of beer. For example, in 1935 there were 750 beer-brewing plants in the United States. By 1978 only 96 plants remained.(34) Five major brewing companies controlled 68 percent of the market in 1976, up from 53 percent in 1971. (35)

In the 1940's there were over 6,000 soft drink bottling plants in the United States; by 1975, as shown in figure 12, there were less than 2,500. (36,37) The four largest brands accounted for about two-thirds of the market in 1974.(38) The structure of the soft drink industry may be altered considerably by the recent FTC decision outlawing territorial franchises for soft drinks in nonreturnables. See page 233.

The History of Return Rates

The effectiveness and impacts of a container deposit system depend on the average number of trips a refillable container makes to market; i.e., on the "trippage." Trippage is related to "return rate, " i.e., the fraction of all refillable containers that are returned and reused, as shown in the following equation:*

Figure 12.—Soft Drink Bottlers in the United States



SOURCE (36, 37)

$$\text{Trippage} = \frac{1}{1 - \text{Return rate}}$$

As the return rate approaches 100 percent, the trippage becomes very large. (See table 62.) To achieve high return rates and therefore high trippages requires both using durable containers and the cooperation of producers, distributors, retailers, and consumers.

Under the industry's voluntary deposit system, beverage container return rates and trippage have decreased over time. The available data on return rates are uncertain because they are based on inference from container and beverage sales rather than on direct measurement. They differ for beer and for soft drinks, by region of the country, and by segment of the market (for example, for the on-premise and the off-premise beer markets.)

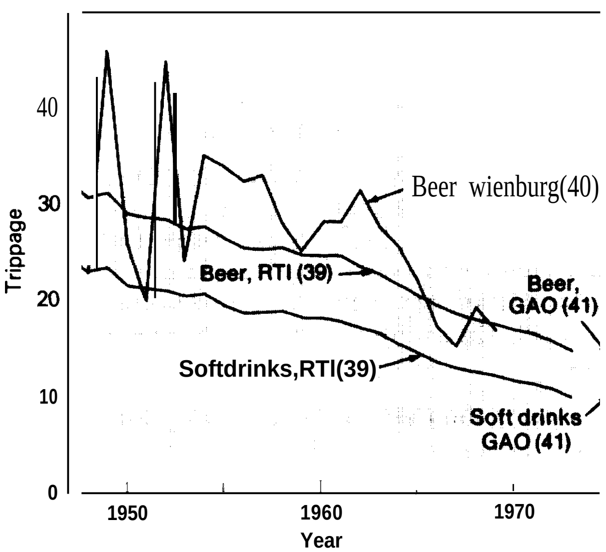
Trippages for the period 1947 to 1973 for beer and for soft drinks are shown in figure 13, taken from estimates by RTI (39) and by Weinberg. Also shown are estimates for 1975 by the General Accounting Office (GAO) .(41) The RTI estimates are based on an inventory model that infers trippage from nationwide beverage and container sales. The basis and scope of the Weinberg data are not known. Since the beer data include both on-premise and off-premise markets, they over-

*Not all returned containers are suitable for refilling. Some are broken during the cleaning and filling operations. The resulting loss of containers, or "shrinkage, " means that customer return rates are somewhat higher than the overall return rate, or refill rate, used here. This difference is small and is ignored in this study.

Table 62.—Relationship Between Return Rate and Trippage

Return rate	Trippage
50 percent	2.0
60 percent	2.5
70 percent	3.3
80percent	5.0
90 percent	10.0
95 percent	20.0
96 percent	25.0
98percent	50.0

Figure 13.— Historical Beverage Container Trippage in the United States



state current trippage in the off-premise, consumermarkets.

The Determinants ofMarket Shares and Return Rates

The decisions of consumers to purchase beverages in refillables and to return the empties for refund depend on the costs and benefits and on the availability of refillables in the marketplace. The consumer benefits include lower shelf prices* for beverages in refillables and the positive feeling of contributing to conservation. The consumer costs include time used to clean, transport, and return containers; storage space; and any forfeited deposits.

Return rates are determined bya number of factors including container durability, the convenience of the secondary packaging system, the ease of return, the amount of the deposit, and consumer choice. Consumers directly control only the last of these factors. The others are controlled by producers, distributors, and retailers, whose decisions are influenced by the market preferences shown byconsumers.

To encourage consumer cooperation the amount of time it takes to return containers for redemption must bekept as small as possible. This can be done by ensuring that containerreturn points are conveniently located and operated; usually at the place where beverages are retailed. The sale and return of beverages in refillable containers are discouraged by sales practices that include failure to stock beverages in refillables, failure to offer refillable beer in six packs, and failure to arrange procedures for convenient returns and deposit refunds. Many consumers may not want to take the time to return containers for deposit. Such consumers probably would not purchase beverages in refillables in the first place, being aware that their total prices, when the forfeited deposits are ineluded, might behigher.

One study found that for stimulating returns the convenience of the return processis more important than the amoun tofthedeposit.(42) This study also noted that the deposit must be set such that the sum of the deposit and the extra costs of handling refillables is lower than the price of a new container; otherwise producers and sellers will discourage returns because the gain from retaining deposits and avoiding return costs would more than pay for the price of new bottles.

Observed market shares and trippage, then, are partly the manifestation of a self-reinforcing system in which declining opportunities for the purchase and return of refillables have led to reduced return rates and to

*prices of beverages in various containers under BCDLare discussed later in this chapter.

reduced refillable market shares. Distributors and retailers have become less likely to stock and accept refillables, which has further reduced opportunities for return and so on, until it is reasonable to expect refillables eventually to disappear from the marketplace.

The near disappearance of refillable bottles is already seen in some urban areas where they are not available in grocery stores, a major point of sale for beverages. * Beer in refillable bottles can only be purchased in certain liquor stores that often sell only a limited selection of brands and these only in case quantities. Some soft drink brands are not packaged in refillables at all, and the analog to the liquor store in which customers might purchase soft drinks in refillables does not usually exist.

Trippage is associated with litter. Bottles are not returned either because they are damaged and thus no longer redeemable, or because the consumer chooses to discard or litter them. Therefore, the greater the chances that a refillable is actually returned (high trippage), the lower are the chances that it will be littered. In addition, there is an incentive for scavengers to retrieve littered refillables for their deposit value. There is very little incentive to recover littered nonreturnables whose scrap value is much less than a 5-cent deposit.

Effectiveness of Beverage Container Deposit Legislation

The potential effectiveness of BCDL can be measured by the extent to which it is expected to achieve its four objectives: reduced litter, reduced use of materials and energy for beverage delivery, reduced solid waste, and establishment of a symbol of materials conservation. In this section, the potential achievement of each of these four objectives is analyzed, based on projections into the future using various quantitative and qualitative models.

Previous projections of the effectiveness of BCDL have been intensively discussed and debated. In order to assist in clarifying the arguments, this section is largely based on a review and comparison of the premises, methods, and results of several existing studies. OTA has also performed new analyses to fill gaps in the literature.

Litter Reduction

BCDL is expected to reduce littering by providing a financial incentive to return beverage containers along with their packaging (trays, six-pack cartons, paper bags) to appropriate retail outlets. BCDL would also provide a financial incentive for retrieving littered containers for their deposit refund. By using market forces, BCDL would operate without appeals to volunteerism, continuous advertising campaigns, or heavy enforcement of antilitter laws. However, BCDL would attack only the beverage container portion of litter; the remainder must be dealt with by other means.

There are two considerations in evaluating BCDL as a litter-control strategy. One is the contribution that beverage containers make to the overall litter problem, and the other is the effectiveness of a deposit system in reducing that contribution. In order to examine these questions, methods of litter measurement and their limitations are first reviewed.

LITTER PRODUCTION AND MEASUREMENT

The rate at which litter is produced varies with the season, with the type of land use (e.g., urban, suburban, residential, commercial, park, roadside), and by region. Litter begets litter: the more litter that accumulates in a place, the more likely are people to litter there. On the other hand, people tend to litter more if they know that cleanup is frequent. Thus, surveying litter at one time by collect-

*Food stamps can be used to purchase soft drinks, but until 1978 could not be used to pay refundable deposits. (43,44) The importance of this factor in stimulating growth of the nonreturnable market share is not known. Food stamps cannot be used to purchase alcoholic beverages.

ing it may affect the results of a subsequent followup survey at the same place at a later time. Not all littering is deliberate; much of it results from improper handling of waste that will be or has been collected. Wind, animals, and uncovered collection and transport vehicles all contribute to the production and redistribution of litter.

There are no agreed upon standard methods for carrying out litter surveys. All are difficult to perform and interpret. Typically, surveys evaluate physical measures such as piece count, volume, or weight. Some use a subjective measure such as esthetic impact. Photometric techniques have also been used, which measure the area of ground covered by the litter. Other approaches weight the physical measures of litter by the degree of degradability or the degree of hazardousness of various items or the cost of collecting them. In all cases, a discrimination must be made between actual litter and naturally occurring objects such as tree branches and stones. For piece count methods, a lower limit of size must be set to avoid overcounting extremely small pieces. In addition to choosing a measurement method, a representative, statistically meaningful sample of the total region to be surveyed must be chosen. Such a sample might consist of randomly selected urban blocks or mile-long highway segments. The report by Syrek for the California State Assembly discusses and illustrates a variety of approaches to litter measurement.(45)

Careful consideration must be given to the selection of a measurement method. For example, in assessing the relative importance in litter of an aluminum can and a glass bottle, each is counted as one item, and they both have about the same volume, but one weighs about 10 times more than the other. Both create the same esthetic blight on the roadside. However, if the bottle is broken, compared with the can or with an unbroken bottle it has a larger piece count, a smaller volume, the same weight, less visibility on the roadside, but is more hazardous to people, animals, and machines. Another example is the relative importance in litter of a steel can and an equivalent weight of paper gum wrappers. The wrappers have a much higher piece count, a greater physical volume, and an equal weight. At the moment of discard the wrappers are more esthetically unattractive than the can, but they degrade quickly and soon can no longer be seen. The can is much easier for litter collection crews to pick up, but if not removed can have a long lifetime in the environment. Compared with the glass bottle, both the can and the wrappers pose little hazard to health, safety, and wildlife.

The apparent significance of beverage containers in litter depends on the measurement technique chosen. Similarly, BCDL can ap pear as if it would have, or has had, a large or a small effect on litter. For example, on a piece-count basis beverage containers are usually outnumbered by pieces of paper. Therefore, using this measurement method even if BCDL were to remove all beverage containers it would appear to have little effect on the total amount of litter. However, the hazard from broken glass would be markedly reduced.

The cost of pickup is not a good measure of the total cost of litter to society. Esthetic blight, safety and health hazards, and lowered property values are all costs of litter that are excluded from pickup costs. Three cases may illustrate the point. A recreational beach may be heavily littered, yet cause little immediate esthetic loss because the people and their gear mask the litter. At the same time, collection costs may be high. Only a tiny fraction of the same litter strewn along a hiking trail may cost little to collect, yet cause considerable esthetic loss. As a third illustration, it may cost the same to collect empty paper cups or bottles from a beach, yet the social cost due to physical injury may be much higher for the bottles. In fact, there is probably little or no correlation between the total costs of litter and the costs of collection.

From these observations, it is clear that any attempt to evaluate the impact of BCDL or of any other program on litter must depend to some extent on subjective judgment. Analysis alone cannot provide an answer. These observations help explain why such differing claims can be made for the impact of BCDL on litter.

BEVERAGE CONTAINERS IN LITTER

Keeping in mind the above noted limitations of surveys and measurement methods, several published estimates of the importance of beverage containers in litter are examined here.

The Maryland State Highway Department surveyed highway litter on seven test sites of 6 miles each in 1974. On September 16 the sites were cleaned, and then resurveyed one month later on October 14. On the later date, an average of 511 beverage containers were collected per mile, or 28.6 percent of all the items collected on a piece-count basis.(46)

A report prepared for the Kentucky Legislative Research Commission in 1975 reviewed 11 surveys of highway litter by both Government agencies and private and volunteer organizations.(47) The contribution of beverage containers to litter by item count ranged from 14 to 51 percent on a "permanent accumulation" basis, and from 15 to 46 percent on areas recently cleaned. One survey in Vermont found that beverage containers account for 90 percent of all litter on a volume basis.(48)

An extensive survey for the California State Assembly on an item count basis found that beverage containers and secondary packaging (excluding pull-tops) comprised 17 percent of all littered items in open highway areas, 18 percent in agricultural areas, and 10 percent in urbanized areas.(45) These results are not comparable to the Maryland and Kentucky findings because the California survey included small items and broken glass on a piece-by-piece basis. The California group found about 200 beverage containers per week per mile of rural road, compared to the 128 per week per mile found in Maryland. A study of highway litter in Oregon found about 7 beverage containers per mile per week with the State BCDL in effect, and about 13 beverage containers per mile per week in Washington, which has a strong litter control act.(49) The California survey also examined litter in recreational areas. No data were given, however, on the portion due to beverage containers.

The EPA has estimated that a total of 4.1 billion beverage containers were littered in 1975.(50) It has been argued that this number is far too high, and that to account for it would require littering the containers for all of the beverages consumed in locations outside homes and commercial establishments. *

IMPACT OF BCDL ON ROADSIDE LITTER: OREGON AND VERMONT

The experiences in Oregon and Vermont provide two, limited data bases on which to judge the expected effect of BCDL on highway litter. Data were gathered on the beverage container content of roadside litter and on the costs of litter control before and after the passage of their deposit laws. These data have been the subject of considerable controversy due in part to sampling errors and to the lack of adequate baseline data and measurement methods. (49,52)

A survey by the Vermont State Highway Department just before and after the deposit law was implemented found a 76-percent reduction in beverage container litter and a 35-percent reduction in the volume of total litter. The same authors report a 31-percent decrease in the cost of litter pickup in Vermont from 1973 to 1977 (pro- and post- law).

In Oregon, thirty l-mile segments of State highways were surveyed by the State Highway Division. Surveys were carried out before the law took effect, during the transition

using the figuer of 150 littered containers Per mile per week based on the California and Maryland surveys and a total of 2.4 million miles of hard surfaced rural road in the United States(51) leads to an estimate of nearly 19 billion littered containers per year on rural roads alone. While this estimate is clearly too high and suggests that the California and Maryland data are not typical of all rural roads, it also suggests that the EPA estimate is not wholly unreasonable.

to the deposit system, and about 1 year after.(54) Litter rates for all items declined by 26 percent from "before" to "transition," and by 39 percent from "before" to "after."* For beverage containers, litter rates declined 72 percent to "transition" and 83 percent from "before" to "after."

Based on these two observations in Oregon and Vermont, as well as on other information, GAO projected a reduction in the beverage container portion of highway litter of 80 percent under BCDL.(56) They further estimated that total highway litter on an item count basis would decline by 7 to 37 percent, depending on whether beverage containers represent a low of 9 percent or a high of 46 percent of all litter. The latter estimate assumes that littering of other items would be unaffected by changed patterns of container littering.

In the analysis of BCDL by RCC, a reduction of total litter volume by 40 percent and a 20-percent reduction in litter item count was projected. Their 20-percent figure is roughly the average of GAO's range of 7 to 37 percent.

EPA projected that under BCDL the number of beverage containers littered in 1980 would decrease by 70 percent to 1.6 billion. Alternatively, using the GAO estimate of an 80-percent drop, and the EPA estimate of total beverage container litter without BCDL, one can estimate that 1.1 billion beverage containers would be littered in 1980.

SUMMARY OF LITTER IMPACTS

The estimates of the significance of beverage containers in litter and of the impact of BCDL on litter in Vermont and Oregon vary widely. Nevertheless, all studies agree that BCDL does or would lead to some reduction in the amount of beverage container litter found on the Nation's highways. No studies are available of the effects of BCDL on urban or recreational area litter. In view of the origins of beverage container litter, it is likely to be reduced more in urban and recreational areas than on highways. Neither estimates of the cost-effectiveness of BCDL as a litter control measure, nor comparisons of the cost-effectiveness of BCDL with alternative approaches to litter control can be made from the available data.(59)

*The Oregon data were re-evaluated by the Wharton School, which calculated declines of 23 and 36 percent respectively for the two periods.

Materials and Energy

BACKGROUND AND SCENARIOS

Several studies have projected the impacts of BCDL on the consumption of materials and energy. These results are reviewed, analyzed, and supplemented in this section.

In the overall production of beverages for market the manufacture of containers consumes the most materials. Lesser quantities are used for secondary packages (six-packs, cartons, cases) and labels as well as for constructing and maintaining capital equipment and buildings.

The use of energy is more diffused throughout the entire beverage delivery system, not only for manufacturing packaging materials and containers but also for transportation, storage, handling, cleaning, and reuse or recycling.

For a given level of beverage sales, the total consumption of materials and energy strongly depends on the market share and the return rate of each container type. In general, producing a refillable bottle requires more materials and energy than a nonreturnable glass or plastic bottle or a metal can of the same size. However, if a refillable bottle is reused a sufficient number of times, this higher resource use is spread out over several trips and the total use of materials and energy per trip is lower, even when the energy required to transport, store, and clean returned containers is included. If the refillable is not reused a sufficient number of times, however, the net consumption of energy and materials would increase under

13CDL. Producing new cans from returned cans rather than from virgin raw materials takes less energy and raw materials even when the energy required to store and return cans is included.

No one has been able to forecast with confidence container return rates and market shares under BCDL. It is the practice to estimate the energy and materials impacts for a reasonable range of these parameters. Some studies identify the critical market share and trippage values below which mandatory deposits would cause an increase in materials and energy use.

Several comprehensive analyses of the impacts of BCDL have been published in the last 5 years. The results of each have been presented in the form of one or more scenarios that describe the conditions that might exist after a law had taken effect. 1n these analyses, each scenario is a set of assumptions about the state of the system under study. (A scenario, which is neither a forecast nor a projection, usually describes a situation that is either extreme, plausible, or typical.)

Significant elements of the 12 scenarios used in 7 studies are summarized in table 63. All of the studies, except the one by the Wharton School, assume that the minimum deposit on all beverage containers is 5 cents. The Wharton School study examines a 5-cent deposit for beer and a 6-cent deposit for soft drink containers, assuming that all are refillable.

Some of the studies do not identify all the elements of the scenarios used. In addition, replication of the results of the studies requires knowledge of the scenarios used to describe the baseline conditions in the absence of legislation, and some of the reports fail to state these assumptions.

MATERIALS

Current Materials Use.—The materials used for containers and closures are glass, steel, and aluminum, with smaller amounts of plastic, paper, and wood. The annual consumption of these materials depends on market shares, return rates, recycle rates for nonreturnable containers, and the weight of materials used in each type of container.

The weights for typical beverage containers of the major types, reported in two key studies, are shown in table 64. The differences reflect the variations among containers used for different brands. Other container sizes are in use, especially for glass nonreturnables. However, it has been shown that the weight of glass required per ounce of beverage delivered is nearly the same for all container sizes .(67] For this reason, calculations of the use of energy and materials can be made with good accuracy using an average container size, In this study, each container type is assumed to have a weight equal to the average of the values in table 64.

OTA estimated the use of glass, aluminum, and steel for beverage containers and compared these results to estimates interpolated from an EPA study, as shown in table 65. Gross tons refer to the weight of all containers produced. Net tons refer to the actual materials used, assuming that various fractions of glass, aluminum, and steel containers are recycled to make new containers. It is not clear why EPA's estimates are higher than OTA'S.

The OTA estimates of gross materials consumed for the production of beverage containers in 1977 are equivalent to 30 percent of the Nation's total annual consumption of glass, 1.3 percent of steel, and 12 percent of aluminum.

The market shares and return rates used to calculate the OTA estimates of 1977 materials use are shown in table 66. According to industry sources, the total consumption of beverages in individual containers in 1977 was 734 billion ounces of soft drinks and 55o billion ounces of beer. (71,72) The total materials use is based on delivering these amounts of beverages to customers.

Future Materials Use for Beverage Containers.—Forecasting the future gross materials use for beverage containers requires forecasting future beverage consump-

Table 63.—Elements of Scenarios Used in Published Evaluations of BCDL

Source	Kind of proposal examined	Date law passed	Date law implemented	Year of scenario	Scenario designation	Return/recycle rates — %: Returnable bottle	Return/recycle rates — %: Non-returnable bottle	Return/recycle rates — %: Cans	Market shares — %: Returnable bottle	Market shares — %: NR bottle	Market shares — %: Steel can	Market shares — %: Aluminum can	Change in consumption of beverages due to law	Technology Change
Department of Commerce (60)	Mandatory deposit	1975	1978	1981	High return rate	90	NA	NA	100	0	0	o	(used 1975)	—
					Low return rate	80	NA	NA	100	0	0	o		—
Environmental Protection Agency (61)	Mandatory deposit	1975	1975	1980	N/A	90	NA	81[a]	80	0	10	o	N	Bottle weights and sizes same as 1975. No plastic bottles.
General Accounting Office (62)	Mandatory deposit	1/1/77	1/1/78	/1/81[a]	Mix I	90	NA	80[c]	48	0	←	[illegible]	No change	No plastic bottles
					Mix II	90	NA	80[c]	80	0	5	[illegible]	No change	
Hannon (63)	Mandatory deposit	—	—	1970	N/A	87.5	NA	NA	100	0	0	o	—	—
Research Triangle Institute(64)	Mandatory deposit	—	late 1970's	1982	Scenario 1	90	NA	79[d]	58	0	24	[illegible]	Reduced 0.2%	All containers to use less energy over time. No plastic bottles.
					Scenario 2	80	NA	70[e]	79	0	12	[illegible]	Reduced 0.2%	
Resource Conservation Committee (65)	Mandatory deposit	1980	1982		Mix I	90	80	80	40	10	←	[illegible]	No change	All containers to use less energy over time. Plastic bottle adopted.
					Mix II	92	86	86	60	5	←	[illegible]		
Wharton School(66)	Ban on cans & nonreturnable bottles, with deposit system.	1969	969	1974	Export bottle[g]	87.5	NA	NA	100	0	o	0	No change[h]	1974 technology used.
					Stubby bottle[g]	87.5	NA	NA	100	0	o	0		

[a]90 percent recycle of the 90 percent of cans returned.
[b]Some results are presented for 1985.
[c]Includes 10 percent reduction to account for processing losses.
[d]87.7 percent of 90 percent to account for processing losses.
[e]87.7 percent of 80 percent to account for processing losses.
[f]Plastic bottle market shares of 10 percent in both mixes.
[g]Wharton considered beer industry adoption of either export (tall-neck) or stubby (short) bottles.
[h]Wharton also examined some impacts of an arbitrary 15 percent reduction in beverage consumption.

Table 64.—Typical Beverage Container Weights in 1975

Container type	Container weight in grams: RTI (68)	Container weight in grams: Wharton School (69)
12-ounce aluminum can	20	20
12-ounce steel can (3 piece)		
Body and bottom (steel)	45	43
Top (aluminum)	5	5
Total	50	48
12-ounce glass beer		
Refillable	283	297
Nonreturnable	173	173
16-ounce glass soft drink		
Refillable	481	425*
Nonreturnable	283	283
16-ounce polyester plastic	37	—
Steel crown for glass bottles	2.25	2.17

'Page 128 of volume II of the Wharton School report is apparently In error. To be consistent with other calculations on page 64 of that report, the 16-ounce refillable soft drink container weight should be 15, not 12 ounces

Table 65.—Materials Consumed for Beverage Container Production in 1977

Material	Annual consumption (million tons): EPA 1977' (net)	OTA 1977b (gross)	OTA 1977c (net)
Glass	7.37	6.52	6.52
Steel	1.59	1.39d	1.26
Aluminum	0.54	0.64e	0.47

aSource OTA interpolation between EPA estimates for 1975 and 1980 (70)
bBased on average container weights in table 64 and 1977 Sales mlx from table
cA~6sumlng recycle rates of 10 percent for steel, 25 percent for aluminum O Per" cent for glass
dIncludes 467 billlon steel crown closures weighing 114,000 tons
eIncludes 106,000 tons of aluminum tops on 19.1 bllllon 3-piece blmetal cans

tion, container market shares, return rates, and container weights. Forecasting net materials use (gross use minus amount recycled) further requires forecasting recycle rates by container type for nonreturnable containers.

Several previous studies have addressed this forecasting problem by investigating materials use under two or more scenarios that might be typical of the future. In this study, a mode of presentation has been adopted that illustrates the future use of materials over a full range of system responses.

Table 67 shows the amounts of container materials required to deliver 1 million ounces of beer or soft drinks using containers of current design, if return and recycle rates are both zero. Figures 14 to 20 illustrate how the amounts of steel, aluminum, and glass required to deliver 1 million ounces of beverages per year depend on the market shares and on the return and recycle rates. *

Summary of Materials Impacts.—The current manufacture of beverage containers uses over 8 million tons of materials, mostly glass. Shifts from nonreturnable to refillable bottles can greatly reduce glass use. Shifts from cans to refillable glass would reduce metal and increase glass use. Since glass refillables weigh from 4 to 10 times more than steel cans and 8 to 20 times more than aluminum cans, a shift from cans to glass bottles would increase the total use of materials on a weight basis. A complete shift to refillable glass would free 1.3 percent of the Nation's steel and 12 percent of its aluminum for other uses. Similarly, total glass use would decline, with the amount depending on the trippage achieved.

ENERGY

Energy use in the beverage delivery system has been examined in a manner similar to that used for materials demand. First, detailed computations are made of the amount of energy required to deliver a certain amount of beverage, say 1 million ounces, in each type of container. Next, projections are made of beverage sales, market shares, return rates, and recycle rates, which together provide a basis for calculating the number of containers of each type. Finally, the energy requirements for each container type are totaled to arrive at the requirement for the overall system.

*Glass use for circumstances not included in figures 17 to 20 can be estimated using these equations, which assume that no glass is recycled.

Gross glass use [tons) to deliver 1 million ounces of heer = [15.!J x [nonreturnable glass market share)] + [26.6 x (1 – return r-ate) x (refillable market share)]

Gross glass usc [tons) 10 rfeliver 1 million oonres of soft drink = [19.5 x (nonreturnable glass market share)] + [31.2 x (1 – return rate) x (refillable market share)]

Table 66.—1977 Container Market Shares and Return Rates

Beverage	Container type	Market share[a]	Ret urn/recycle rate[b]
Beer	Refillable glass	13	0.92 (12.5 trips)
	Nonreturnable glass	27	—
	Steel	19	0.10
	Aluminum	41	0.25
Soft drink.	Refillable glass	40	0.90 (10 trips)
	Nonreturnable glass	22	—
	Steel	27	0.10
	Aluminum	11	0.25

apercent by by volume of alpackaged beverages sold Source Industry data (71 .72.73)
bOTA estimates based on GAO (41) and RTI (39)

Table 67.—Gross Materials Required to Deliver 1 Million Ounces of Beverage in Each Type of Container

Container type	Material	Gross materials required (tons) Beer	Soft drinks
Refillable glass.	Glass	26.6 12 oz.)	31.2 (16 OZ.)
	Steel crowns	0.2	0.15
Nonreturnable glass	Glass	15.9 12 oz.)	19.5 (16 OZ.)
	Steel crowns	0.2	0.15
Steel can *(3* piece)	Steel	4.04	4.04
	Aluminum lids	0.46	0.46
Aluminum can	Aluminum	1.84	1.84

Basis Table 64 Assumes recycle and return rates of zero.

Summary of Previous Findings on Energy Use By Container Type.—In the study done by the Wharton School for USBA, the findings of several studies on energy use for various container types were conveniently summarized in a figure reproduced here as figure 21. Each of the studies has included energy required for material production, for container fabrication, for washing, for all forms of transportation and delivery including truck fuel, for heating and cooling of storage space including consumer refrigeration, and energy required for recycling or reuse. Such total energy analyses necessitate the synthesis of data from many sources and are always subject to considerable error. Nevertheless, figure 21 suggests that most authors are in reasonable agreement on the basic facts of beverage container energy use per unit of beverage delivered.

Return Rates and Energy Use: An Illustration.—The energy required to deliver 1 million ounces for each container type can be conveniently divided into two portions: one portion is fixed, independent of return or recycle rate; the other declines as return or recycle rate increases. The fixed portion represents the energy that must be used in every filling for container washing, filling operations, warehousing, shipping, and retailing and storage, as well as the energy used in transportation, reuse, and recycling. For refillable bottles, the variable portion represents the energy required to produce a bottle, distributed over all its trips or fillings. For a nonreturnable bottle or can, the variable portion is the energy required to produce a bottle or can, taking into account that the average energy used decreases as the recycle rate for its materials increases. Even if a con-

Figure 14.—Steel Required to Deliver a Total of 1 Million Ounces of Beer or Soft Drink Without Recycle for Various Market Shares for All Cans and Aluminum Cans

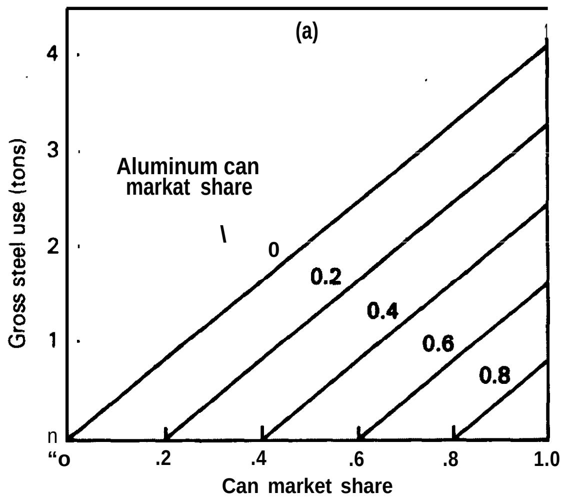
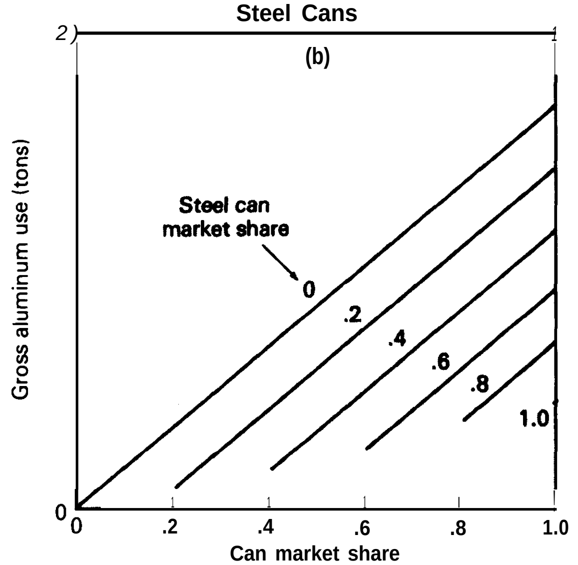


Figure 15.—Aluminum Required to Deliver a Total of 1 Million Ounces of Beer or Soft Drink Without Recycle for Various Market Shares for All Cans and Steel Cans

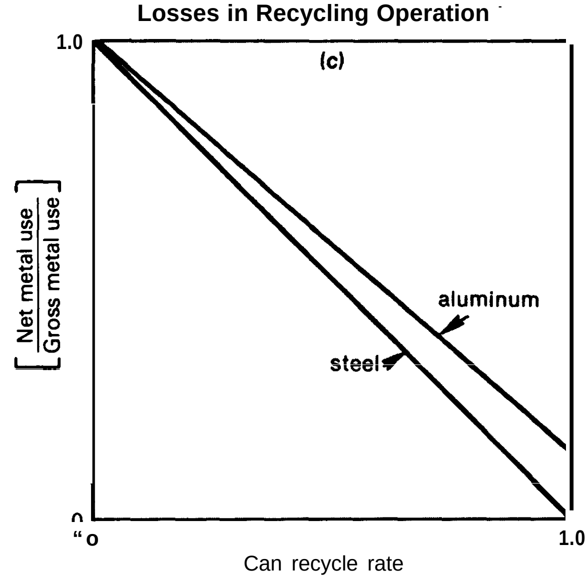


tainer were reused or recycled an indefinitely large number of times, total energy use per fill could never drop below the fixed value required in each cycle.

The following equation expresses the relationship of the energy use to the return rate for beverages in returnable containers:

Total energv use per fill – Fixed energy [use per fill] [illegible]

Figure 16.— Impact of Can Recycle Rate on Metal Consumption for Beverage Containers. Recycle Rate for Aluminum is Limited to 87 Percent bv Metal Losses in Recycling Operation



The equation shows that as the return rate approaches 1.0 or 100 percent, the contribution to total energy use of the energy to make a container approaches zero. For a glass refillable bottle, the energy to make a container is typically three times as great as the fixed energy use per fill. Figure 22 shows how the total energy use per fill decreases with return rate, if the fixed energy is 1 unit and the energy to make a container is 3 units.

Figure 22 can be used to help establish a rough relationship between energy use in refillable and nonreturnable bottles. According to table 64, a typical nonreturnable bottle weighs approximately 60 percent as much as a typical refillable. It is reasonable to assume that the energy to make a container is directly proportional to the weight of a glass bottle, and that for a nonreturnable it is therefore about 60 percent of 3 units or 1.8 units. Furthermore, for a nonreturnable, fixed energy use per fill is less than that for a refillable, since return, storage, and transportation energy uses are lower. It is reasonable to assume that fixed energy use per fill would be roughly 50 percent of that for a refillable, or 0.5 unit. Thus, total energy use per fill for a nonreturnable might be roughly 1.8 + 0.5 or

Figure 17.–Glass Required to Deliver a Total of 1 Million Ounces of Beer if the Can Market Share Is Zero and No Glass Is Recycled

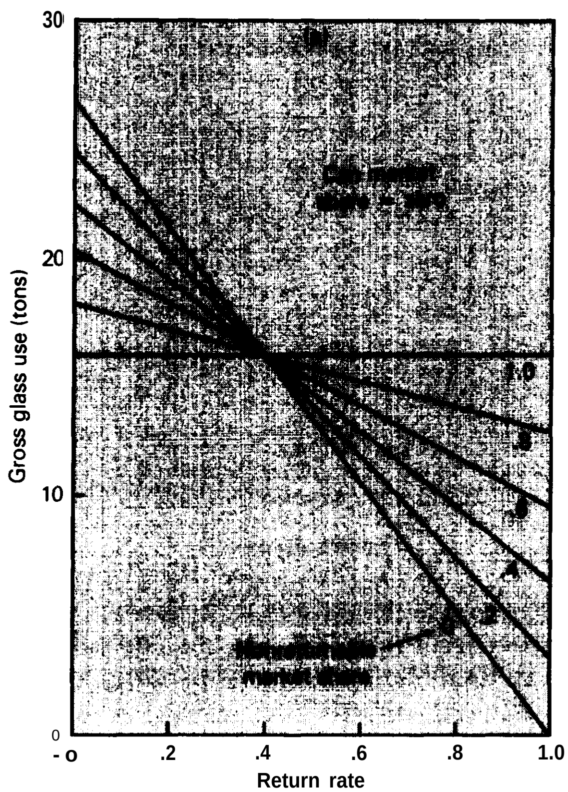
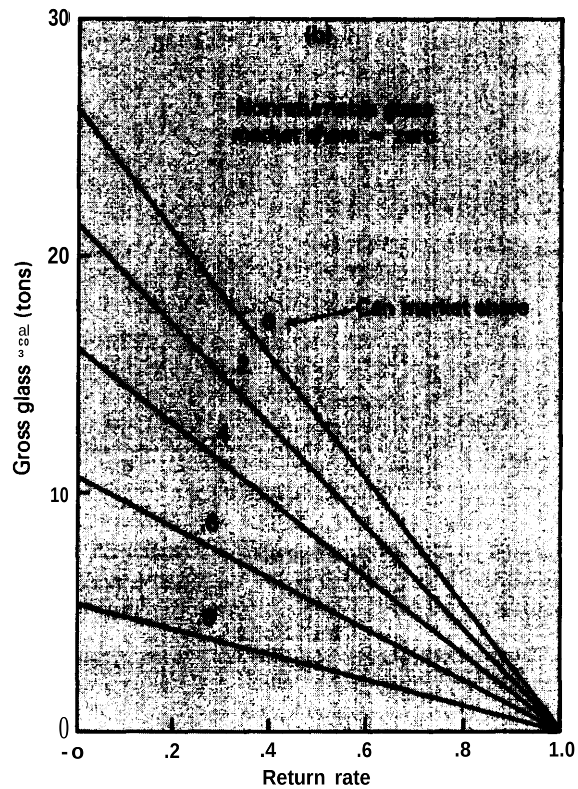


Figure 18.–Glass Required to Deliver a Total of 1 Million Ounces of Beer if the Nonreturnable Glass Market Share Is Zero and No Glass Is Recycled



2.3 units per fill. Comparison with figure 22 suggests that in this case refillable and nonreturnable bottles use the same amount of energy if the return rate is as high as 56 percent (trippage = 2.3). For return rates higher than 56 percent, refillables use less energy than nonreturnables.

Return Rates and Energy Use: The Literature.—Several previous studies have calculated the return rates, or trippages, required for energy use for refillable glass containers to "break even" with nonreturnable glass. These results are summarized in table 68. All authors place the break-even trippage between 1.5 and 3.3. While trippages between 1.5 and 3.3 represent a significant range (return rates from 33 to 70 percent), they nevertheless fall below most projections of return rates under a deposit system. Thus, an all-refillable bottle system would use less energy than an all-nonreturnable bottle system. *

The relative energy use for refillable glass bottles and for nonreturnable, but recyclable, aluminum and steel cans must also be considered. Less energy is required to produce a new can from scrap metal than from virgin ore even if the energy to return the used cans is included. Thus, as recycle rates for cans increase, average energy use per new can declines. In addition, each type of can has different values of both fixed energy use and energy to make a container. To make complete comparisons, therefore, total energy use per ~ill for refillable bottles at various

*Recycling waste glass to make new bottles saves only small amounts of energy. These studies have not taken into account this route to new bottles.

Figure 19.—Glass Required to Deliver a Total of 1 Million Ounces of Soft Drinks in a Mix of Refillable and Nonreturnable Bottles if the Can Market Share Is Zero and No Glass Is Recycled

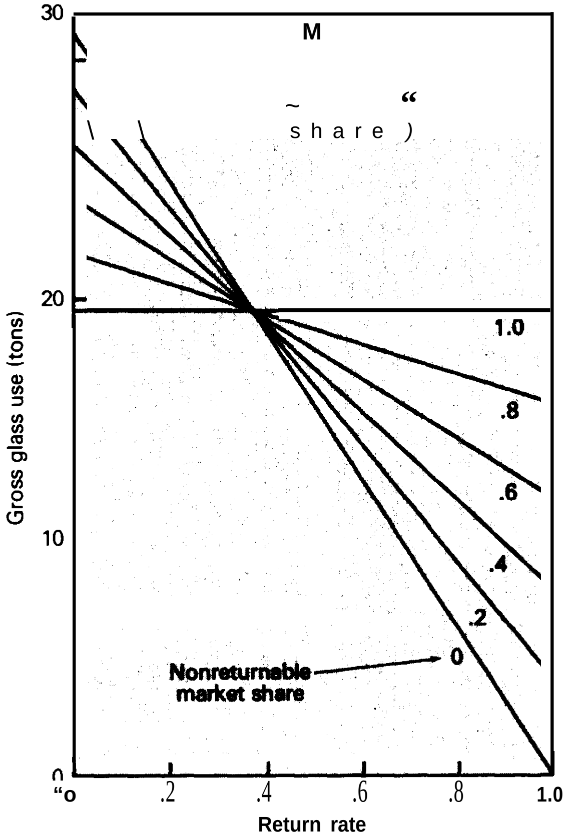
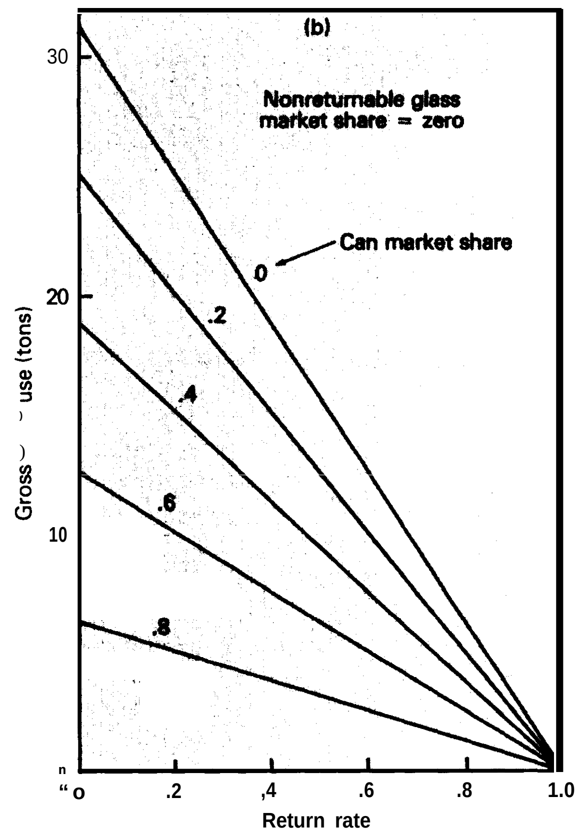


Figure 20.—Glass Required to Deliver a Total of 1 Million Ounces of Soft Drinks in a Mix of Refillable Bottles and Cans if the Nonreturnable Glass Market Share Is Zero and No Glass Is Recycled



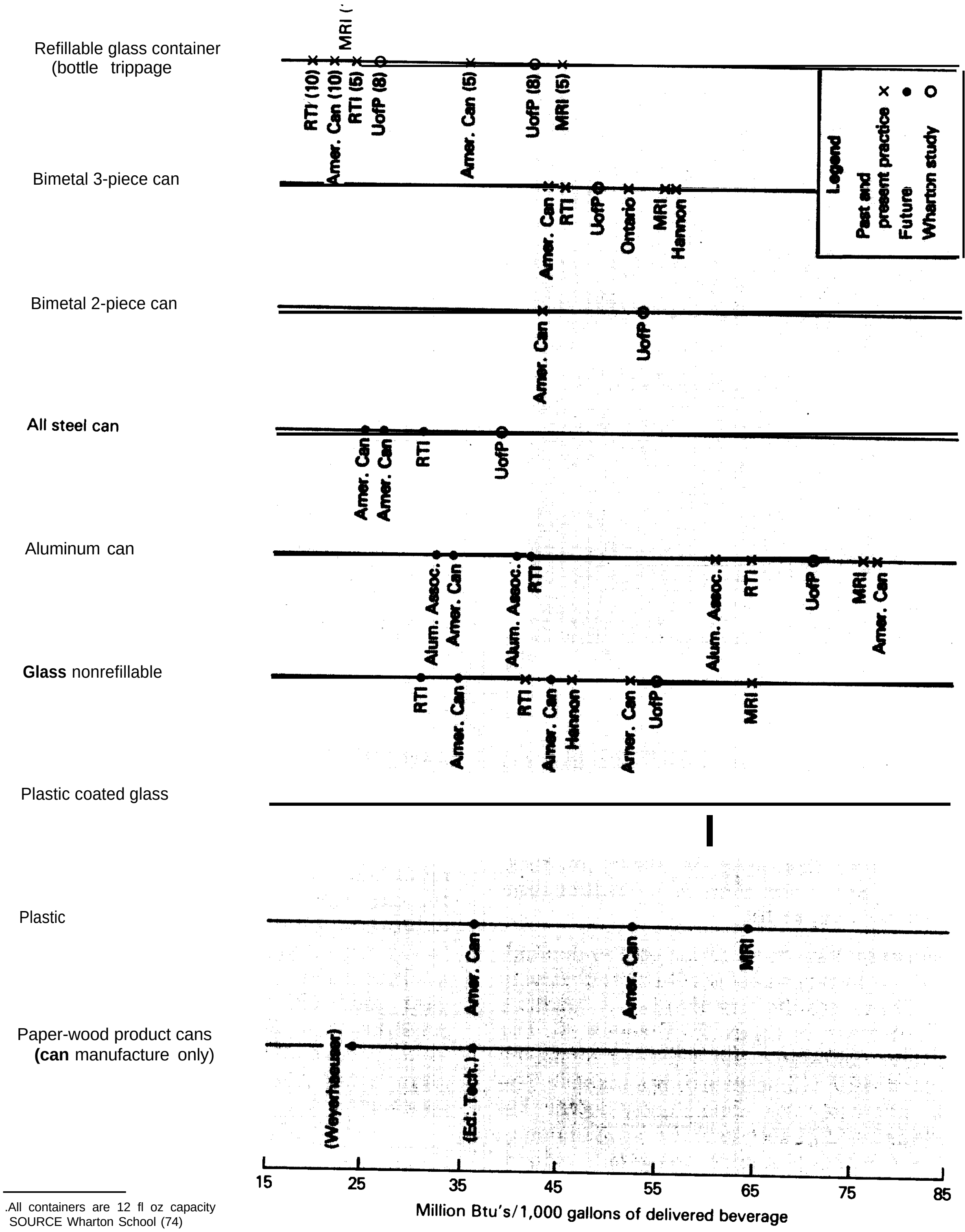
return rates must be compared with that for cans at various recycle rates. Since soft drink bottles typically contain 16 ounces while cans contain 12 ounces, the comparison can be more usefully displayed in terms of total energy use per ounce of beverage rather than total energy use per fill.

Several studies have reported the dependence of total energy use on return and recycle rates. These results are displayed together for comparison in figure 23 through 25. For each beer container, the Midwest Research Institute (MRI) estimates are the highest. The GAO estimates are consistently lower because they are based on RTI's projections to 1985, when it is assumed container technology will be improved. The RTI and GAO projections for recycled cans in 1985 differ somewhat because of GAO's treatment of a technical point in recycling. *

Figures 23 through 25 can be used to identify energy tradeoff points between pairs of containers, for each study. Table 69 shows the can recycle rates that would have to be achieved if total energy use per fill were to be lower than that for refillable bottles, at each of three bottle return rates. Table 69 means that generally aluminum-can recycle rates must be 10 to 20 percent higher than bottle return rates if cans are to use less energy than returnable bottles. Steel cans are unable to compete with glass refillables on an

*GAO assumed that an 80-percent recycle rate would translate to the production of only 70 percent of new cans from scrap due to scrap loss on remelting.

Figure 21 .—Comparison of Total Energy Requirements by Container for Off-Premise Package Beer as Presented by Various Investigations*



.All containers are 12 fl oz capacity
SOURCE Wharton School (74)

Figure 22.— Dependence of Total Energy Use Per Fill on Container Return Rate (schematic illustration)

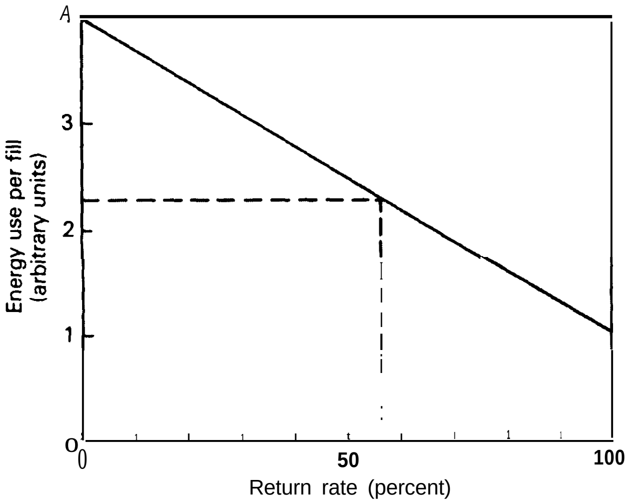


Table 68.— “Break-Even” Return Rates and Trippages for Equal Energy Use in Refillable vs. Nonreturnable Bottles

Breakeven point: Return rate (%)	Breakeven point: Trippage	Source	Beverage type
60	2.5	GAO (75)	—
33	1.5	RTI (76)	soft drink
50	2	RTI (76)	beer
70	3.3	DOC (77)	
62	2.5	Wharton (78)	beer
35	1.5	Wharton (78)	soft drink
50	2	Hannon (63)	soft drink
56	2.3	illustration on page 199	—

SOURCE Office of Technology Assessment

energy basis if bottle return rates exceed 65 percent (or 70 percent for soft drinks according to the Battelle study).

Total Energy Use in the Beverage Delivery System.—Using the background data on per-unit energy use described above, along with projections of beverage consumption, market shares, and return and recycle rates; seven of the BCDL studies estimated current energy use for beverage delivery and/or projected future use with and without deposit legislation. The various estimates and projections are compared in this section.

Figure 23.—Total Energy Use for Beverage Delivery in 12-Ounce Aluminum (—) and Steel (---) Cans in Years Noted

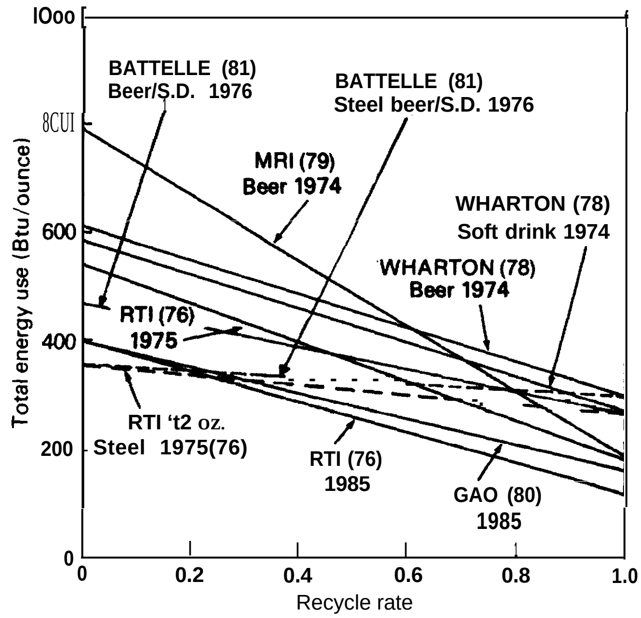
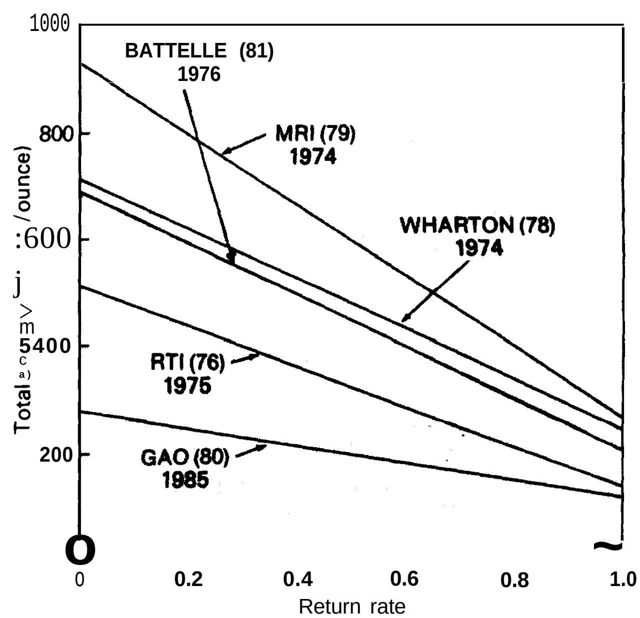
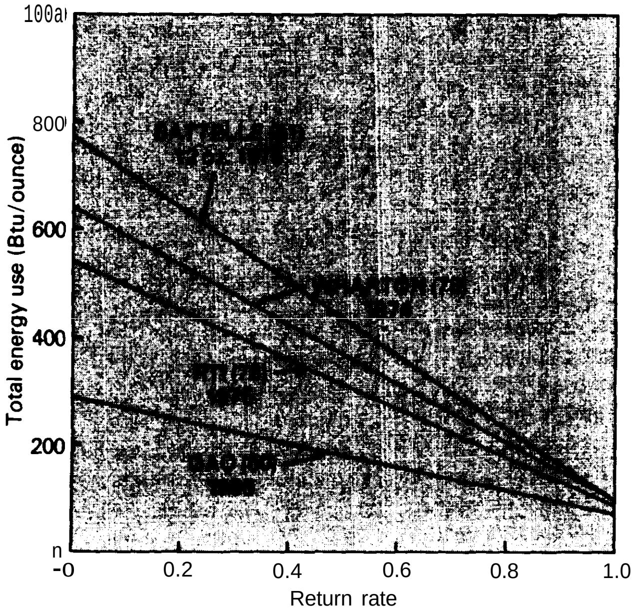


Figure 24.—Total Energy Use for Beverage Delivery in 12.Ounce Refillable Bottles for Beer



All these systemwide energy use calculations attempt to include all energy used for beverage delivery, including materials production, container production, washing, filling, transportation, wholesaling, retailing, and return and recycling. The energy con-

Figure 25.—Total Energy Use for Beverage Delivery in 16-Ounce Refillable Soft Drink Bottles



sumed by workers and their families in their nonworking life, the energy used by consumers who make special trips from home to retail store to return containers, and the energy consumed by alternative consumer purchases with money saved by buying lower priced beverages (the so-called "re-spending" effect, see page 205), are all specifically excluded.

Table 70 summarizes the findings of seven studies of system energy use under BCDL for various scenarios. The scenarios of the Commerce Department, Hannon, and the Wharton School all assume that only refillable bottles are used. The return rates used range from 80 to 90 percent in these three studies. The EPA, RTI, GAO, and RCC scenarios feature mixes of cans and bottles at various market shares.

The most significant feature of table 70 is the general agreement regarding potential energy savings under a deposit system. The estimates range from 21- to 61-percent savings, clustering around 40-percent savings. The high estimates of 56- and 61- percent savings by the Wharton School and the Com-

Table 69.-Typical Tradeoffs of Total Energy Use Between Refillable Bottles and Recyclable Cans Using 1974-76 Technology

Study	Bottle ret urn rate	Can rec cle rate for equal Jnergy use	
		'Aluminum	Steel
Beer			
RTI (64)	T o y .	80%	none •
Wharton (66).	7 0 ° / 0	72%	—
MRI (79).	i ' O°/ o	!?i4°/o	—
Battelle (81)	70"A	580/0	any* •
RTI (64)	800/0	920/o	none*
Wharton (66).	80%	89%	—
MRI (79). ... , ...	800/0	65Y0	—
Battelle (81)	80Y0	85%	none •
RTI (64)	90%	100!40	none •
Wharton (66).	9 0 Y 0	100?40	—
MRI (79).	900/0	750/0	—
Battelle (81)	90?'fo	n o n e	none •
Soft **drink**			
RTI (64)	70940	89Y0	none •
Wharton (66).	700/o	none*	—
Battelle (81)	700/0	900/0	none*
RTI (64)	800/0	100 "/0	none*
Wharton (66).	80Y0	none *	—
Battelle (81)	80Y0	none •	none •
RTI (64)	9o"A	none •	none •
Wharton (66).	90Y0	none •	—
Battelle (81)	90~0	none •	none •

"Total energy use for cans at all recycle rates is higher than that for refillable bottles at this return rate
" .Total energy use for cans at any recycle rate is less than that for refillable bottles at this or lower return rates

merce Department reflect the assumption that a highly efficient, all-glass refillable system would result from BCDL. The lowest estimate of 21-percent savings by RCC reflects a scenario based on the retention of significant market shares for cans and nonreturnable bottles, and on low estimates of return and recycle rates.

The various studies use different baseline time periods and different baseline values for beverage consumption, market shares, and returrdrecycle rates. Thus, one cannot meaningfully compare the future baseline energy requirements nor the absolute levels of energy use under a deposit law. The estimates for 1975 energy consumption are a more meaningful basis for comparing the various studies, since they are founded on actual industry data or on 1- or 2-year extrapolations

Table 70.—Total System Energy Use for Beverage Delivery: Literature Estimates of Deposit Impact Under Various Scenarios

			Future energy use			
				Energy savings under deposit law		
Source	1975 energy use (10^{12} Btu)	Year	No deposit law baseline energy use (10^{12} Btu)	(10^{12} Btu)	(“/0 of baseline)	Scenarios
Commerce Dept. (82) . . .	4 6 1	?	461	280	61	90 °/0 RR: all refillables
	461		461	181	39	80 40 RR: all refillables
EPA (70)	465	**1980**	585	245	42	90% ret. & recyc. rates: all refillables
GAO (83)	—	**1985**	363	116	32	Mix I
	—	1985	363	155	43	Mix II
Hannon (63).	—	1980	—	—	40	80°/0 RR: all refillables
RTI (84).	358	1982	383	168	44	Scenario 1
	358	1982	383	144	38	Scenario 2
Resource Conservation	—	1985	334		21	Mix I
Committee (85)	—	1985	334	1 ; :	39	Mix II
Wharton School (86). . . .	—	1974	407	147	36	87°/0 RR: all export refills.
	—	1974	407	226	56	87°/0 RR: all stuby refills.

a see table 63 for scenario details

from such data. The Wharton estimate can be included in this group because it is based on actual 1974 statistics. The differences among the studies of the total energy use by the beverage delivery system in 1974/1975 arise from the different estimates of energy used per unit of beverage delivered.

The impact of BCDL on national energy demand can be approximated using the data in table 70. The average of the estimates for energy use by the beverage delivery system in 1975 is 425 trillion Btu (including Wharton's 1974 estimate escalated to 1975 by 3 percent). This is about 0.60 percent of the total national energy use in that year. The studies suggest that 40 percent of the energy used by the beverage delivery system would be saved under BCDL. In 1975, this savings would have been 170 trillion Btu or 0.24 percent of the total national energy use. For perspective, 170 trillion Btu per year is equivalent to 80,000 barrels per day (bpd) of petroleum or to the output of ten 1,000-MWe electric powerplants, or to about one-eighth of the energy supply potential of the Nation's MSW. (See chapter 5.) However, the energy savings estimates range from 20 to 61 percent. This range translates to an overall savings of O.12 to 0.36 percent of national energy demand, or to the equivalent of 40,000 to 120,000 bpd of petroleum.

Types of Energy Saved Under BCDL.—Changes in energy use would differ for various fuel types under BCDL; in fact, use of some forms of energy might actually increase if there were a strong shift from nonreturnables to refillables. Fuel use by source for each type of container has been examined by RTI,(87) Wharton, and Battelle.(81)

RTI estimated that in 1975 the actual beverage delivery system was based on oil (37 percent); coal (29 percent); natural gas (26 percent); and nuclear, hydropower, and wood wastes (8 percent). RTI did not attempt to project the future distribution of energy use by fuel type due to the uncertain nature of future energy markets. However, from data presented on page 27 of the RTI report, the conclusion can be drawn that compared with a lo-trip refillable bottle more natural gas and more coal are used to produce nonreturnable bottles and aluminum and steel cans. Nonreturnable bottles and aluminum cans also require more oil, while bi-metal steel cans require less oil than refillable beer bottles, but more than 16-ounce refillable soft drink bottles at 10 trips. Thus, according to RTI a shift toward a lo-trip refillable system would reduce the use of coal and natural gas, but would have a small effect on oil use, which could go up or down.

Battelle's estimates of the shifts in energy use by fuel type are based on _ete replacement of all cans used in 1~76 with refillable glass bottles that achieve trippages of 4 for off-premise consumption of beer and 10 for soft drinks. (Beverage sales in nonreturnable bottles were assumed to be unchanged.) For this shift, Battelle estimated total energy savings of 67 trillion Btu per year but an increase in oil consumption of 11 trillion Btu, [~quivalent to about 5,000 bpd].(90) However, Battel!e's estimates of energy use are among the lowest for cans and the highest for refillable bottles. (See figures 23 to 25.) Thus, their estimates of fuel shifts may overstate the increase in oil use.

Wharton estimated fuel-specific energy shifts for complete conversion of all beverage containers to refillables in 1974.(88) For a system of 8-trip refillables for both beer and soft drinks, (an optimistic trippage level) they estimated savings in all forms of energy, including oil. For a system of 3-trip refillables (a pessimistic trippage level) they projected savings in all forms of fuel except oil, for which increases in use ranged from 5 to 26 trillion Btu per year (i.e., 2,000 to 12,000 bpd), and natural gas, for which a small increase might occur under a doubly pessimistic outcome,

These three studies together suggest that energy use would decrease under BCDL for each fuel form, with the possible exception of oil. For the case of oil, some of the estimates also suggest a savings. However, Wharton's pessimistic 3-trip scenario shows an increase in oil use, as does Battelle's study. In view of these findings, as well as the current emphasis on fuel switching toward coal in industry and electric power generation, and of the current trend toward more energy efficient transportation vehicles and appliances, the future consumption of energy by fuel type remains clouded at best. The available estimates do not suggest a heavy increase in oil use under BCDL, even though increased fuel use for delivery trucks is included.

Limitations of the Energy Impact Analyses.—Two limitations must be attached to the energy savings estimates presented above. First, the uncertainty in the potential for energy savings of deposit legislation is large. It is unlikely that further modeling efforts can reduce this uncertainty significantly due to the unpredictable nature of the system response in terms of beverage sales, market shares, and recycle/return rates. However, every study has found that energy use in the beverage delivery system would decrease under a deposit system.

Second, reduced consumer expenditures under a deposit system might actually increase total national energy consumption. This might take place if beverage prices decline under a deposit law. Then consumers would have additional disposable income that might be spent on goods and services having a higher energy intensity per dollar than beverage containers. Suppose, for example, that average beverage prices were to decline by I cent per 12-ounce container under a deposit law and that 40 percent of the energy use were saved on average, or about 150 Btu per ounce. The marginal energy savings would then be 12 ounces multiplied by 150 Btu per ounce and divided by 1 cent, or 180,000 Btu per dollar. If prices were to decline by 2.5 cents, the marginal energy savings would be 72,000 Btu per dollar. The average energy intensity of consumer expenditures has been estimated to be about 68,500 Btu per dollar. (91) Thus, if prices decline by as much as 2.5 cents per 12-ounce container and if that 2.5 cents is spent on average personal expenditures, the energy savings from a deposit system might be eliminated. Smaller price decreases than this, however, would not eliminate the energy savings. Of course, if prices of beverages do decline under BCDL, consumers would gain the benefit of greater disposable income. Furthermore, the very idea that beverage prices will decline under a deposit system has been challenged by its opponents. (See page 221.)

Summary of Energy Impacts.—There is broad agreement in all major studies on the amount of energy used to deliver soft drinks and beer. Furthermore, most studies agree on the break-even point for trippage or return rates required in order that refillable bottles use less energy than nonreturnables: generally 1.5 to 3.3 trips. All of these estimates of break-even trippage are on the low side of expectations for BCDL. Similarly, most studies agree that aluminum cans must achieve recycle rates that are 10 to 20 percent higher than bottle return rates in order to break even on an energy basis. Most studies find steel cans unable to compete with refillable bottles on an energy basis at any recycle rate, if bottle return rates are 70 percent or higher.

Seven major studies of BCDL estimate energy savings of 20 to 60 percent, clustered around 40 percent of total system use, or about 170 trillion Btu per year. This is equivalent to 0.24 percent of the total national energy use, or to 80,000 bpd of oil, or to the output of ten 1,000-MWe powerplants, or to the fuel content of one-eighth of the Nation's MSW. The uncertainty in this number is large—it might lie in the range of 20 to as much as 61-percent savings; i.e., from the equivalent of 40,000 to 120,000 bpd of oil.

Most estimates suggest that all forms of fuel would be saved under BCDL, but some studies suggest a small increase in oil use. In no case are large increases in oil use expected, even including truck fuel.

If consumer prices of beverages under BCDL drop by 2.5 cents or more per container, the energy saved by BCDL might be offset by increased consumer expenditures for other purposes. Smaller price decreases would offset only a part of the energy savings.

Finally, all studies project a decrease in energy use for beverage delivery under BCDL. It is unlikely that further analyses or additional studies of experiences in States having BCDL can reduce the uncertainties in these estimates.

Solid Waste Reduction

BCDL would affect the generation rate and the composition of solid waste by changing the amounts of container and secondary packaging materials that are discarded. Eventually, nearly all beverage container materials are discarded as solid waste or as permanent litter. A portion of these discards are recycled into new products. Other parts, especially refillable bottles retired by bottlers and brewers, become industrial waste that is not included in the MSW total, but that may be recycled into new bottles.

In this section, various literature estimates of the impact of BCDL on solid wastes are summarized and compared. In addition, detailed estimates are made of the impact of BCDL on MSW composition and amount under five scenarios that describe possible outcomes of BCDL. These estimates serve as a basis for evaluation of the literature estimates, and as a basis for assessing the interaction of BCDL with source separation and centralized resource recovery.

BEVERAGE CONTAINERS AND TOTAL SOLID WASTE: THE LITERATURE

Table 71 summarizes available estimates from the literature of the impacts of BCDL on the rate of solid waste generation. Estimates of reductions in total MSW due to BCDL range from 1 to 5 percent by weight. Estimates of reductions in weight of beverage container material discards range from 24 to 78 percent. As is the case with estimates of energy use, most authors caution that they present scenarios, rather than predictions of the most likely outcomes.

By any reasonable standard, a reduction of total solid waste tonnage by 1 to 5 percent can be considered as small, but not insignificant. In the near term, this tonnage reduction would be unlikely to reduce the cost of waste collection. However, disposal costs are more likely to be reduced in direct proportion to the

Table 71.—Beverage Containers in Solid Waste: Literature Estimates

		Beverage containers in solid waste (million tons)		Percent by weight of MSW		Percent reduction due to BCDL		
Source	Year	No BCDL	With BCDL	No BCDL	With BCDL	Container materials	Total MSW	Comments
Commerce Dept. (92).	?		(Reduction of 4.8 million tons with deposits)					$x)70 RR:all refill.
EPA (70)	1975	8.8	—	—	—	—	—	—
	1980	10.6	3.4	6	2	69	5	90°/0 RR:all refill.
GAO (93)	1985	10.5	2.3	5.2	1.1	78	4	Mix I
	1985	10.5	3.2	5.2	1.6	70	3.6	Mix II
RTI (94) total	1982	9.4			2.6		3.2	Scenario I
glass	1982	(6.87)	(::;7)	(::;)	(2.6)	(::)	(1.6)	Scenario I
steel	1982	(1.93)	(0.13)	(1.2)	(0.1)	(93)	(1.1)	Scenario I
aluminum	1982	(0.56)	(0.04)	(0.3)	(0.02)	(93)	(0.3)	Scenario I
Resource Conservation	1985	6.3	4.8	3.8	2.9	24	1	Mix I
Committee (95)	1985	6.3	3.1	3.8	1.9	51	2	Mix II

SOURCE: Office of Technology Assessment

reduction in waste load. At $6 per ton for disposal, a 4-percent reduction in the 135 million tons of MSW generated nationwide each year would represent a savings of $32 million annually in disposal costs. At a typical cost of $30 per ton for both collection and disposal of MSW, the maximum savings would be $160 million per year. This estimate does not depend on whether collection is done by municipal employees or by private firms.

IMPACT OF MANDATORY DEPOSITS ON WASTE COMPOSITION

BCDL would change not only the amount but also the composition of MSW because the discard rates for glass, steel, and aluminum would be altered. This alteration in composition might cause the potential revenues from the recovery of materials from waste by either source separation or centralized resource recovery to change. This section presents estimates of the range of composition changes that might be expected on a nationwide basis.

This analysis has four important limitations. First, the content of glass, steel, and aluminum in MSW varies widely from place to place, so nationwide estimates may be inadequate for evaluating local effects. Second, beverage container contributions to solid waste depend markedly on market shares and return rates, even within reasonable ranges of expectations for the future. Third, technologies for separating out marketable aluminum and glass in centralized resource recovery are still developmental at best, and the economics of separate collection of cans and glass are often marginal. For these reasons, it is optimistic to attribute any net revenues to the recovery of container materials, other than steel from resource recovery. Finally, as a first approximation, it is assumed in this analysis that all materials used to produce beverage containers eventually become solid waste discards that are either recycled or disposed of. This assumption overstates the content of each material in solid waste by a small, unknown amount, since it includes containers that are littered or otherwise lost from the system.

In this analysis the impact of BCDL on waste composition is examined as if such legislation had been in effect in 1975. Noncontainer waste materials (both “gross discards” and “net disposed of”) are assumed to be the same as those reported by EPA for 1975 as shown in table 72. Beverage sales in individual containers in 1975 are assumed to be unchanged by the deposit law. They are 594 billion ounces of soft drinks and 517 bil-

Table 72.—Non.Beverage Container Contents of MSW in 1975
(million tons)

Material	Gross discards	Net waste disposed of
Paper	44.1	37.2
Glass*	7.4	7.2
Ferrous metals*	10.0	9.5
Aluminum*	0.5	0.5
Other metal	0.4	0.4
Product organics	14.9	14.7
Food and yard waste	48.8	48.8
Misc. inorganic	1.9	1.9
Total	128.0	120.2

'Does not-Inlcude beverage container portion of these materials
SOURCE Adapted from EPA data (96)

lion ounces of beer. (71,72) Individual container weights are those given in table 67. (The container portion of MSW calculated in the following paragraphs is different from the values reported by EPA.(96))

Several scenarios are examined to illustrate how the effects of deposit legislation depend on return rates and market shares. These include a baseline case with no BCDL and four scenarios with BCDL in effect. The scenarios are described in table 73. Scenario I is the baseline, designed to represent the actual situation in 1975. Scenarios II and HI, based on an all-refillable glass system, are designed to show the effects of the complete disappearance of aluminum and steel beverage containers. For these two scenarios, glass waste is estimated for both 80- and 90-percent return rates. Scenarios IV and V illustrate high and low market shares for cans. Under the high can share of Scenario IV it is further assumed that the remaining refillable bottle purchasers will be more consistent returners (RR = 90 percent) than they would be under the low can share situation (RR = 80 percent). In either case, under the deposit system, can recycle rates are assumed to be 10 percent lower than bottle return rates to account for material losses in the recycling process and for the expected tendency of can customers to make fewer returns.

Using the assumptions of the five scenarios, the beverage sales estimates, and the methods and data of pages 194 and 195, the gross discards and net disposal rates for glass, steel, and aluminum containers were calculated. These results are presented in table 74. The calculated percentage decreases in beverage container materials in MSW are in general agreement with the literature scenarios in table 73.

The composition of MSW under each of the scenarios was also estimated. These results are presented in table 75 for the "net disposed of" situation, since it is more likely to be representative of the composition of curbside MSW than is "gross discards. "

For the five scenarios, BCDL is estimated to remove at most ST percent of the aluminum, 11 percent of the ferrous metal, and 36 percent of the glass, although not all three at the same time. The impact on ferrous metal content is small because only about 11 percent of all the ferrous metal in MSW comes from beverage cans. The glass and aluminum percentages are larger because beverage containers make up about 47 percent of all the glass and 40 percent of all the aluminum in MSW. In Scenario II, for an all-refillables system with an 80-percent return rate, the glass content of waste increases by about 2 percent. For an all glass refillables system with a 70-percent return rate, glass content of waste would rise by 25 percent to 17 million tons. However, this low return rate is less likely than the 80 or 90 percent used in Scenarios IV and V.

The impacts of the change in waste composition on both source separation and resource recovery depend on projections of the efficiencies of materials recovery and on net unit revenues from materials sales. These impacts are addressed in detail in chapter A for source separation and in chapter 6 for resource recovery, based on the scenarios in table 75. It is estimated in these chapters that successful BCDL might cause a revenue loss of 4 to 5 percent for a resource recovery plant optimized before the legislation takes effect, and a maximum revenue loss of 25 percent for a residential source separation program.

Table 73.—OTA Scenarios for Estimation of the Impact of Deposits on Solid Waste Composition in 1975

		Market shares					Return/recycle rates				
		Scenario					Scenario				
Beverage	Container type	I	II	III	IV	V	I	II	III	IV	V
Beer	Steel	28	0	0	30	10	0.10	—	—	0.80	0.70
	Aluminum	32	0	0	40	20	0.25	—	—	0.80	0.70
	Refillable glass	16	100	100	30	70	0.927	0.80	0.90	0.90	0.80
	Nonreturnable glass	24	0	0	0	0	0	—	—	—	—
Soft drink	Steel	27	0	0	30	10	0.10	—	—	0.80	0.70
	Aluminum	5	0	0	20	20	0.25	—	—	0.80	0.70
	Refillable glass	47	100	100	[redacted]	70	0.905	0.80	0.90	0.90	0.80
	Nonreturnable glass	21	0	0	[redacted]	0	0	—	—	—	—

Scenario I Baseline 1975. 0 deposit law
Scenario II All refillable glass, 80-percent return rate
Scenario III All refillable glass, 90-percent return rate
Scenario IV High can market shares
Scenario V Low can market shares

Table 74.—Beverage Containers in MSW Under Five Scenarios in 1975 (million tons)

	Gross discards[a]					Net disposed of[b]				
	Scenario					Scenario				
Material	I	II	III	IV	V	I	II	III	IV	V
Glass	6.33	6.46	3.23	1.35	4.52	6.33	6.46	3.23	1.35	4.52
Aluminum	0.46	0	0	0.69	0.42	0.33	0	0	0.13	0.12
Steel	1.28	0	0	1.33	0.44	1.15	0	0	0.27	0.13
Total	8.07	6.46	3.23	3.37	5.38	7.81	6.46	3.23	1.75	4.77
Percent drop in total from scenario I	—	20	60	58			17	59	78	39

a No recycle of used glass, aluminum, ors beverage containers
b includes recycle of aluminum and steel cans at the rastes shown in table 73

Table 75.–Composition of MSW in 1975 Under Five Scenarios ["Net Waste Disposed Of"]

	Amount (million tons)					Weight percent				
	Scenario					Scenario				
Material	I	II	III	IV	V	I	II	III	IV	V
Paper	37.2	n.c.•	n.c.	n.c.	n.c.	29.0	29.4	30,1	30.5	29.8
Glass	13.5	13.7	10.4	8.6	11.7	10.5	10.8	8.4	7.0	9.4
Ferrous metal	10.7	9.5	9.5	9.8	9.6	8.4	7.5	7.7	8.0	7.7
Aluminum	0.8	0.5	0.5	0.6	0.6	0.6	0.4	0.4	0.5	0.5
Other metal	0.4	n.c.	n.c.	n.c.	n.c.	0.3	0.3	0.3	0.3	0.3
Product organics	14.7	n.c.	n.c.	n.c.	n.c.	11.5	11.6	11.9	12.0	11.8
Food and yard waste	48.8	n.c.	n.c.	n.c.	n.c.	38.1	38.5	39.5	40.0	39.1
Misc. inorganic	1.9	n.c.	n.c.	n.c.	n.c.	1.5	1.5	1.5	1.6	1.5
Total* •	128.0	126.7	123,4	122.0	124.9	99.9	100.0	99.8	99.9	100.1

Basis: Tables 72 and 74.
•No change
"Total percents do not add to 1000 due to rounding

BCDL AS A SYMBOL OF CONSERVATION

The fourth objective of BCDL supporters is to establish such a law as a symbol of natural resource conservation. The importance of working towards or achieving such a symbol cannot be judged objectively. Because the deposit law issue has been argued so widely at local, State, and national levels, many citizens and decisionmakers have taken strong positions pro and con.

By any objective measure of materials and energy conservation, the attention given BCDL has outweighed its potential for resource savings compared with other conservation approaches. Such measures as auto gasoline mileage standards, appliance performance labeling, and thermal performance standards for buildings can save more energy. By leading to reduced auto weight, auto mileage standards can also save more materials than can BCDL.

The symbolic importance of BCDL as a conservation measure has two identifiable subjective bases. Litter is the first of these; beverage containers make a uniquely visible and hazardous contribution to litter. The second is that to some people beer or soft drinks are unnecessary or undesirable products. For them, not only do containers create litter and waste resources, but they also symbolize a waste of money and human resources as well. Perhaps it is not surprising then, that deposit laws have received so much attention.

It is, of course, understandable that BCDL has strong opponents. If such legislation were passed, various groups expect to lose profits, income, or jobs. Reductions in the use of materials and energy mean declines in the outputs of various industries and thus job losses in them, even as jobs would be gained in beverage production and delivery. Costs of beverage distribution would increase at the wholesale and retail levels, and decline in bottling and brewing. The uncertainties about the extent and incidence of direct economic losses and gains are perhaps as important as the losses and gains themselves. Since no one has been able to demonstrate conclusively whether shelf prices will go up or down (see page 221), proponents and opponents emphasize decreases and increases respectively in order to influence voter attitudes in referenda on BCDL. The following section examines some of the impacts, losses, and gains in detail.

Unintended Effects of BCDL: Impacts, Issues, and Options

Introduction

It is widely recognized that BCDL may have unintended impacts in addition to effects on litter, energy, materials, and solid waste. In this section, a number of these impacts are examined in order to assist in decisions about whether the benefits of BCDL are worth the costs, and in order to identify potential actions that might be taken if BCDL were passed.

These impacts have several salient characteristics. First, since the purpose of BCDL is in part to internalize some of the external costs of container production and use, it follows that some of the impacts are redistributive in character. In other words, in comparison with the situation without deposits, some parties will be better off and some worse off under BCDL. This is especially true in the case of labor impacts—some new jobs are created but others are lost.

Second, assessment of many of the impacts is highly uncertain, either because their determination requires making the same somewhat arbitrary assumptions about system responses to BCDL that were made in assessing its effectiveness, or because the impacts are qualitative and predicting their nature and degree is necessarily judgmental.

Third, the impacts are largely unintended; that is, proponents of BCDL do not intend that they should occur. Thus, proponents and opponents alike presumably have a strong interest in ameliorating those impacts that adversely affect various groups. Because

BCDL represents a change in the rules of the economic game, there is reason not to penalize those whose gains under the old rules may be threatened by the new ones. On the other hand, the parameters of economic life change frequently for many reasons. It is, therefore, important to retain incentives in the economic system to motivate people to make effective adjustments to new conditions.

In the subsequent sections, impacts, issues, and options are discussed in eight areas:

1. capital costs of production and delivery of beverages,
2. employment and wages,
3. costs and prices,
4. beverage availability and consumption,
5. environment,
6. health and safety,
7. new technology, and
8. government

Existing analyses by various parties are used, where available, as a basis for the discussion. Quantitative predictions are compared with respect to assumptions and findings, following the approach used in the previous section on the effectiveness of BCDL. Six major sources of such information are studies by RTI,(64) the Wharton School, the Department of Commerce (DOC),(60) GA0,(62) EPA,(61) and RCC.(65)

Capital Costs of Beverage Delivery under BCDL

INTRODUCTION

The delivery of beer or soft drinks in refillable bottles requires a greater capital investment than delivery of the same amounts of beverage either in nonreturnable bottles or in cans. This is true for several reasons: (i) can-filling lines are less expensive, more productive, and physically smaller than are bottle-filling lines, (ii) cans and, to a less extent, nonreturnable bottles are lighter and smaller than refillables, and (iii) nonreturnables avoid the costs of plant, equipment, and vehicles required for storing and returning used containers.

Under BCDL, the expected shift toward refillables would thus require a greater capital stock* than would have been required in the absence of such a law. Calculation of this difference has proven to be conceptually and practically difficult, as has its interpretation in terms of additional annual investment and production cost per fill. There is disagreement over the correct typical price of various capital equipment and plant items such as filling lines, bottle washers, storage space, and delivery vehicles. Furthermore, the productivity of such plant and equipment is treated differently by different authors. The degree to which existing capital stock for nonreturnables can be converted to use for refillables has been disputed, as have the costs of such conversions. In addition, it has not been shown that firms in the relevant industries use minimum capital investment as a strategic objective, so calculations based on optimum utilization of capital may be unrealistic. Finally, there is disagreement over the proper bounds on the industries and the items to be included—some authors treat expenditures for refillable bottle inventory, or "float," as a capital cost, while others treat float as a recurring expense. Some authors include changes in the capital investment required for producing container materials and for fabricating containers, while others do not. In analyzing changes in the total costs of beverage delivery under BCDL, ignoring the capital requirements of the container and material producers is equivalent to assuming that the prices paid by brewers and bottlers for containers would not be affected by BCDL. Under any outcome of BCDL, the output and capital requirements of can producers would decline. Bottlemakers would suffer a large decline in output and would convert some capacity from making nonreturnables to making refillables.

*Capital stock is the undepreciated dollar value of all the plant and equipment required to put in place the capacity to deliver a given amount of products each year.

CAPITAL STOCK NEEDS PER UNIT OF OUTPUT

RTI presented the data in table 76 on the capital stock used by various industries and subindustries in order to deliver 1 million ounces per year of beer and soft drinks in each of three container types.(gT) From table 76 it can be seen that refillable bottles require more capital stock for brewers, bottlers, distributors, and retailers. On the other hand, container producers require more capital stock for nonreturnables since several times more nonreturnable containers are needed than refillables.

Industry sources have criticized RTI's unit capital requirements, but have not provided equivalent data that could be presented here. * In their review of RTI's report for USBA, R. S. Weinberg and Associates suggested that based on a survey of brewers, $17.50 to $22.50 might be a reasonable estimate of investment per annual barrel of capacity needed to convert to delivering beer in refillables. Twenty dollars per annual barrel is equivalent to $5,040 per million ounces per year, as compared with RTI's estimate of $5,422 per million ounces per year required for brewers and wholesalers to build new refillable capacity. Since it came

*The Wharton School study for USBA is based on alternative cost data, but the presentation of the data does not include an equivalent summary nor can it be easily extracted from their report. The DOC and RCC studies provide no such data, (60,65) GAO used the RTI data,(62)

Table 76.—Capital Stock Required to Deliver 1 Million Ounces of Beverage Per Year in 1982

	Capital stock (1974 dollars)		
	Refillable bottle system	Nonreturnable bottle system	Metal can system
Beer system			
Brewers and wholesalers	$5,422	$3,713	$2,974
Filling lines	(1,519)	(1,123)	(774)
Production and distribution space	(2,210)	(1,404)	(1,162)
Distribution equipment	(1,200)	(848)	(768)
Other	(492)	(338)	(270)
Retailers*	1,325	—	495
Equipment	(87)		
Space	(1,238)		(195)
Container producers	284	2,850	1,089
Total	$7,031	$6,563	$4,558
Soft drink system			
Soft drink bottlers and canners	$5,827	$4,229	$2,774
Filling lines	(2,679)	(1,993)	(940)
Distribution space	(1,188)	(836)	(704)
Distribution equipment	(1,200)	(848)	(768)
Other	(760)	(552)	(362)
Retailers*	1,325	—	495
Equipment	(87)	—	
Space	(1,238)	.	(195)
Container producers	596	1,697	1,107
Total	$7,748	$5,926	$4,376

* Retail space and equipment required for handling returned containers
SOURCE RTI (97)

from a survey of brewers who were asked how much it would cost them to convert under BCDL, there may be an upward bias in Weinberg's estimate.

CAPITAL IMPACTS OF BCDL

Four ways could be used to estimate the impact of BCDL on capital needs and costs in the beverage delivery system. In each case, the length of the transition period from the passage of BCDL to full implementation is an important parameter. With longer transition periods there is more opportunity for firms to replace or to decommission equipment as it reaches the end of its useful life, rather than prematurely.

An estimate of the lower bound on the capital costs of conversion to BCDL can be obtained by subtracting the total capital stock required without BCDL to produce the industry output in some future year from that required with BCDL. The difference is the extra capital investment required by BCDL. The total capital stocks required for each of the two cases are estimated by multiplying the unit capital stock requirements in table 76 (or their equivalent from another source) by the total beverage consumption and by market shares for each container type; followed by summing up the requirements for the three kinds of containers. The problem with this approach is that it assumes that all existing capital can be converted or liquidated at no cost. Since this is not the case, this method gives capital impacts that are too low.

A better estimate of the capital costs of conversion can be obtained by taking account of the fact that not all of the capital stock that would be used without BCDL can be converted for use with BCDL. For example, for most scenarios, the market shares of cans will decline under BCDL. Thus, some portion of capital stock in can-filling equipment will be retired from service early and be written-off as a loss, and it will have to be replaced with bottle-filling equipment. This shift makes the investment in new capital larger than the first estimate.

A third approach to estimating the capital costs of the transition to BCDL would be to ask firms what costs they anticipate. Besides the incentive for firms to overstate such costs in order to emphasize the negative effects of BCDL, it would be most difficult to obtain a clear picture of the future scenarios implicit in such estimates. The Wharton School used this approach in cooperation with R. S. Weinberg and USBA.(99) Their task was simplified by the stated assumption that all cans and nonreturnable bottles would be banned under the proposal they studied.

An even better estimate might be made by taking into account the uncertainties that industrial managers would face during a transition to BCDL. Since they cannot foresee with confidence what the market shares and beverage sales will be under BCDL, managers are unlikely to make perfect investment decisions. To ensure their ability to meet demands, they might overinvest in new equipment. On the other hand, in the face of an uncertain future they may choose to underinvest, and to meet changed demands by operating with higher utilization of existing refillable capacity until the nature of the new sales pattern is clarified. Other factors that might be taken into account include abnormal increases in capital equipment prices in the face of a surge of demand caused by BCDL, as well as the possibility that less expensive conversion technologies might be developed to facilitate the transition. It is not clear whether this improved estimate would be higher or lower than any of the first three.

Table 77 presents a summary of estimates of the capital cost impacts of BCDL from the literature. This table also shows the length of the transition period, the year the transition would be completed, the method used for the estimate, and indications of the scenarios used.

The range of estimates in table 77 is so wide as to preclude any suggestion that there is a consensus. The Wharton School and Department of Commerce estimates are obviously too high for BCDL because they are based

Table 77.—Estimated Additional Capital Costs Due to BCDL: Literature Values[a]

Source	Additional capital costs of BCDL (million dollars) Total	Beer	soft drinks	Other	Estimating method	Transition time (years)	Year of cost estimates	Scenario[b]
Deparment of Commerce (100).	1,970-2,990	1,700-2,610	270-380	15-20[f]	industry testimony	3-4	1975	all refillables
	—	—	600-1,000'	—		—	—	—
EPA (101)	1,780d	1,235e	545'	—	gross costs	several	1975	800/0 refillables
	1,915	254	272	1,376	early writeoffs	several	1975	800/0 refillables
RTI (102).	824	604	897	-6769	lower bound	4	1974	Scenario I
	2,006	1,067	1,314	– 3749	lower bound	4	1974	Scenario II
GAO (103)	818	342	476	– 5g9	adjusted	3	1974	Mix I
	2,448	1,387	1,061	– 1139	lower bound	3	1974	Mix II
Wharton School (104)	3,500	2,252'	1,248'	—	lower bound & industry survey	5	1971-73	Export bottle
	3,165	1,952'	1,213e	—		5	1971-73	Stubby bottle

[a]All estimates exlude cost of assitional refillable Container inventory, or float
[b]see table 63 for details of scenarios
[c]Industry critique of Department of Commerce estimate (100)
'Includes "float "
[e]Retall costs divided equally between beer and soft drinks
'Vending machines
[g]Container producers

on a transition to an all-refillable bottle system. On the other hand, the RTI and GAO* estimates are too low since they are "lower-bound" values that overstate the degree to which existing capita] can be converted to different uses. More realistic estimates might be derived from the RTI data by adding the costs for the beer and soft drink industries without subtracting the negative capital costs they attributed to the decrease in output in the container industries. This calculation gives total costs of $1,501 million and $2,381 million for RTI's Scenarios I and 11 respectively,

Table 77 suggests that the capital costs of BCDL to brewers, bottlers, distributors, and retailers might range from $2 to $3 billion, distributed over 3 to 5 years. This implies an annual rate of additional capital investment due to BCDL of $0.4 to $1.0 billion per year. By contrast, EPA reports that these industries were investing in new capital at the rate of $0.4 to $0.6 billion per year during the period I970-75.(1o1) Assuming that this rate would have prevailed without deposit legislation, then as a rough estimate, BCDL might require a doubling of the rate of capital investment in these industries for a 3- to 5-year period. Beyond the transition period, capital costs per unit of output would continue to be larger due to the higher investment per unit required to support industry growth.

A further consideration related to capital stock impacts is the cost of additional refillable container inventory, or float, necessary to support the system under BCDL. Estimates of the additional cost of float during the transition to BCDL range from $1.0 to $1.6 billion. As GAO notes, however, this cost is very much lower than the savings from not purchasing nonreturnables during the same period.

The energy saved by BCDL will reduce the need for new capital equipment for energy supply, conversion, and distribution. A previous section estimated energy savings under BCDL in 1975 equivalent to 40,000 to 120,000 bpd of oil. Recent estimates for the capital investment needed to produce a new supply of energy range up to $3,000 for coal, up to $10,000 for oil and gas, and up to $100,000 for electric power per bpd of oil equivalent.(106) At $10,000 per bpd, the 40,000- to

*GAO did make some unspecified adjustments to account for limits on the conversion of existing equipment.(105)

120,000 bpd” equivalent saved by BCDL translates to capital cost savings in the energy supply industries of $400 million to $1.2 billion. While this estimate could be carefully refined to reflect the fuel mixes needed under different scenarios, this approximation suggests that capital savings in the energy supply industries could be a significant fraction of the additional capital costs in the beverage delivery industries.

POLICY OPTIONS FOR CAPITAL IMPACTS

The two major kinds of capital-related impacts that might occur under BCDL require different kinds of policy responses. The can- and bottle-making firms may undergo considerable dislocations; some would cease growing and some would suffer very large, and perhaps fatal, sales decreases. Labor contracts in the container industry could put a heavy burden on firms for income maintenance in the face of plant shutdowns or layoffs. At the same time, the beverage delivery industries may be faced with the problem of raising large sums for new investment in an uncertain business environment.

For the container-making industries, policy options include financial assistance through direct grants, Government purchase of plant and equipment, accelerated capital depreciation, or assistance for plant modification to produce new products. (Complementary assistance to employees is discussed in a later section.)

The problems of the container industries could also be ameliorated by insuring that the transition to BCDL is gradual by providing for an implementation period of 2 to 4 years. This strategy would allow a more orderly redirection of company effort. However, it maybe ineffective if firms choose to delay the changeover in the hope that BCDL would be repealed prior to its implementation.

Policy responses to the investment problems of the beverage delivery industries (brewers, bottlers, wholesalers) would be somewhat different from those for the container industries. The uncertainties of both the regulatory environment and the response of the delivery system to BCDL might make investors wary. For example, if a firm were to purchase expensive bottle-filling equipment for refillables under BCDL, and if the new law were subsequently modified in response to political pressure, that firm would be left holding costly, unused equipment. Thus, such investments might appear to be imprudent if the political climate seems uncertain.

Under these conditions, some form of risk sharing by the Federal Government might be appropriate through, for example, loan guarantees, interest subsidies, or cost sharing. Such programs must be designed and administered in a way that avoids stimulating overinvestment while remaining fair and not overburdensome for participating firms.

The needs of small retail stores that depend heavily on beverage sales must be given careful consideration, since they often lack adequate storage space. Some State laws have allowed special beverage container redemption centers to be setup to help relieve the storage problem of small stores. The difficulty with this approach is that it may create a new barrier to the convenience of container return for purchasers, while at the same time weakening the sales base of small stores. In view of these drawbacks and the administrative costs of certifying official redemption centers, it maybe more desirable to let such centers emerge, if they will, as responses to market needs rather than through legislation.

Impacts on Employment and Labor Costs

BCDL would increase both the size of the labor force and the labor costs associated with beverage delivery, while redistributing jobs away from container manufacture toward container handling. Jobs would be shifted geographically from regions where containers are manufactured to regions where beverages are produced and sold. This section summarizes and compares the published evidence of BCDL’S impacts on labor and wages, and discusses related policy issues and options.

UNIT LABOR REQUIREMENTS FOR BEVERAGE DELIVERY

RTI estimates (107) of labor requirements to deliver 1 million ounces of beverages in each of four container systems are reproduced in table 78. Like their unit capital stock estimates, these labor needs have been challenged; however, equivalent alternative estimates have not been made available.

The RTI estimates contain some unexplained omissions; in particular no retail labor is attributed to nonreturnable bottles and cans. In the RTI study, the retail labor for refillable bottles is the extra labor required to manage returns. To be consistent, however, some extra labor should also have been attributed to the recycling of cans. Because of these omissions RTI probably underestimated the number of new jobs that would be created in the retail sector under BCDL.

Within the limitations noted above, the RTI estimates suggest that beverage delivery in refillable containers requires 47 to 86 percent more labor than delivery in nonreturnable bottles and cans. Furthermore, they show that the increased use of refillables would lead to a gain in jobs in all phases of beverage production and distribution. Job losses would occur in the materials and container manufacturing industries.

JOB SHIFTS, GAINS, AND LOSSES UNDER BCDL

Several studies have estimated the size of job shifts, gains, and losses that might occur under BCDL for various scenarios. It is important to differentiate between a job shift and a job gain or loss. A job shift represents a net change in the total number of persons employed in an industry or a sector over a period of time. An estimate of the number of jobs shifted does not account for the actual number of jobs gained or lost in specific trades or industries, or for the difference between a gradual reduction in employment through attrition and retirement, and one that occurs suddenly through layoffs and termination. The actual number of persons who might lose their jobs due to BCDL would be smaller if the transition period is long enough that the labor force is reduced through attrition and retirement.

Table 78.—Average Unit Labor Requirements in the Beverage Delivery System in 1982

	Jobs Der million ounces per year							
	B				Soft drinks			
			Metal can system				Metal can system	
	Refillable bottle system	Non-returnable bottle system	Steel	Aluminum	Refillable bottle system	Non-returnable bottle system	Steel	Aluminum
Container manufacturing								
Glass containers	0.010	0.094		—	0.021	0.071	—	—
Metal cans	—	—	0.062	0.062	—	—	0.062	0.062
Metal manufacturing	—	—	0.022	0.025	—	—	0.023	0.040
Beverage producers and distributors	0.209	0.149	0.139	0.139	0.197	0.095	0.146	0.146
Production	(0.031)	(0.031)	(0.031)	(0.031)	(0.039)	(0.039)	(0.039)	(0.039)
Distribution	(0.178)	(0.1 18)	(0.107)	(0.107)	(0.158)	(0.056)	(0.107)	(0.107)
Retailers	0.108	—	—	—	0.089	—	—	—
Total	0.327	0.243	0.223	0.226	0.308	0.166	0.231	0.249

SOURCE: Research Triangle Inst te (107)

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Table 79 summarizes estimates from the literature on net total job shifts for all industries under BCDL. All the studies project a net increase in total employment. However, as in the case of capital investment requirements, it is difficult to discern a consensus among these studies on anticipated net job additions. The Wharton School estimates are the largest by far; if extrapolated to the 1980-85 period they would approach 200,000. Wharton's estimates are expected to be high since they are based on an all-refillable bottle system. On the other hand, the DOC estimates were made on the same basis and are the lowest. The GAO and RCC scenarios represent less change in the total beverage system than the other studies, and they give generally lower net job additions.

The six studies summarized in table 79 all present estimates of job gains and losses in each of the affected industries. In each case, job gains would occur in beverage distribution and job losses would occur in metal and container production. These results are summarized in table 80 (job gains) and table 81 (job losses). Jobs lost are divided among metal production, canmaking, and bottlemaking. The highest losses in metal production and in canmaking would occur for situations in which bottles capture all or most of the market. Similarly, bottlemaking losses would be smallest for the all-refillable bottle case; even then, however, the labor needed for the production of refillable bottles would be somewhat less than that for the production of a mix of refillables and nonreturnables without BCDL.

As shown in table 80, estimates of job gains by sector differ widely. In general, with BCDL bottlers would need more additional labor than brewers. However, the combination of brewers and wholesale beer distributors would require labor force increases roughly equivalent to those for bottlers, because the bottler data include the soft drink distribution labor. Estimates of job gains in retail trade vary widely, largely because of the poor quality of the data base on labor requirements in retail trade for handling refillables. Finally, Wharton's full simulation of the economy identified another 93,000 new jobs in other industries. Inclusion of these jobs helps to explain why Wharton's estimates of net new jobs in table 79 are so much higher than the others.

Three points stand out in this review of labor impacts of BCDL. First, there is general agreement that under BCDL jobs would be lost in metals production and in container manufacture and that jobs would be gained in beverage distribution, especially in retail trade. Second, studies differ widely on the actual numbers of job gains and losses. Third,

Table 79.—Total Job Shifts Due to BCDL: Summary of Literature Estimates

Source	Scenario [a]	Date	Net number of new jobs [b]
Department of-Commerce (108) . . .	All refillable	1980	13,000-33,000
EPA (109).	800/0 refillable	1980	82,000
GAO (1 10)	Mix I	1981	20,300
	Mix II	1981	41,300
Research Triangle Institute (1 11). . .	Scenario 1	1982	117,700
	Scenario 2	1982	116,900
Resource Conservation Committee (1 12)	Mix I	1985	54,000
	Mix II	1985	53,300
Wharton School (1 13)	Export bottle	1974	137,950C
	Stubby bottle	1974	131 ,150C

[a] see table 63 for scenario details
bFull.time job equivalents in materials, container, brewing, bottling, wholesaling, and retalling Industries (total gains minus total losses)
[c] Includes job shifts in entire economy

Table 80.—Job Gains in Beverage Distribution Under BCDL: Summary of Literature Estimates

Source	Scenario[a]	Date	Brewers	Bottlers	Beer Wholesalers	Retailers	Other
			Total number of new jobs gained				
Department of Commerce (108)	All refillable	1980	~ 60,000-75,000			“35,000-40,000	—
EPA (109) .	80% refillable	1980	*8,300*	35,000	23,100	97,900	—
GAO (1 10)	Mix I	1981	700	11,300	10,400	27,700	—
	Mix II	1981	7,400	28,000	37,500	29,700	—
Research Triangle Institute (11 1). . . .	Scenario 1	1982	– 100(loss)	25,800	14,100	115,700	—
	Scenario 2	1982	– 100(loss)	32,500	26,600	100,500	—
Resource Conservation Committee (1 12). .	Mix I	1985	19,500			59,200	—
	Mix II	1985	38,300			64,300	—
Wharton School (1 13)	Export bottle	1974	12,370	30,100	16,750	33,600	93,000b
	Stubby bottle	1974	12,370	30,100	12,870	32,740	—

a see table 63 for scenario details
b Based on simulation of the entire economy

Table 81 .—Job Losses in Container Production Under BCDL: Summary of Literature Estimates

Source	Scenario*	Date	Metal product ion	Can making	Bottle making
			Total number of jobs lost		
Department of Commerce (108)	All refillable	1980	25,000	35,000	22,000
EPA (109)	80°10 refillable	1980	18,500	34,000	29,700
GAO (1 10). ., ...	Mix I	1981	30,700		
	Mix II	1981	61,400		
Research Triangle Institute (1 11). ...	Scenario 1	1982	6,500	15,800	15,500
	Scenario 2	1982	14,300	35,000	– 6,700 (gain)
Resource Conservation Committee (1 12),	Mix I	1985	5.600	14,200	4,900
	Mix II	1985	10,900	28,000	10,400
Wharton School (1 13)	Export bottle	1974	10,000	33,000	4,870
	Stubby bottle	1974	—	33,000	6,940

“ See table 63 for scenario details

there would be a shift from high-skill, high-wage jobs in the metals and container industries, to low-skill, low-wage jobs in distribution and retailing.

The preceding observations suggest that BCDL would create entry-level positions at the expense of established, skilled workers. Two factors might help to alleviate the job loss problems in metals production. First, only a small part (a maximum of 1.3 percent) of steel production would be affected. Second, automobile companies are currently expressing concern about limited future aluminum supplies and they might absorb any aluminum output made available by BCDL.

The job loss situation in can and bottle production would be considerably more serious. Beverage containers now account for over 40 percent of all steel cans, 96 percent of all aluminum cans, and 50 percent of glass bottles. Obviously, large declines in the output of beverage containers would create serious problems for both workers and firms in these industries,

WAGE IMPACTS OF BCDL

It was shown above that under BCDL the total number of jobs is likely to increase, but that the average skill level would decline. Table 82 shows literature estimates of the im-

Table 82.—Total Employee Compensation Impacts of BCDL: Summary of Literature Estimates

Source	Scenario[a]	Date	Current dollar year[b]	Annual wage changes (million dollars) Net for all industries	Total gains	Total losses
EPA (114)	80% refillable	1980	1976(?)	+ 403	+ 1,292	– 889
GAO (115)	Mix I	1981	1974	+ 201	+ 493	– 292
	Mix II	1981	1974	+ 503	+ 1,164	– 661
Research Triangle Institute (116)	Scenario 1	1982	1974	+ 879	+ 1,285	– 406
	Scenario 2	1982	1974	+ 936	+ 1,505	– 569
Wharton School (113)	Export bottle	1974	1974	+ 649	+ 1,150	– 501
	Stubby bottle	1974	1974	+ 559	+ 1,082	– 523

[a]see table 63 for scenario detail.
[b]Base year in which dollars are measured

pact of the job shifts on the total wages paid annually, as well as on the total gains and the total losses in wages. In each study, the wage losses would occur in metal production and container manufacture and the gains would occur in the beverage production and delivery industries. All sources agree that the net wages paid would increase and that total gains would outweigh total losses by a ratio of approximately 2 to 1.

OTHER LABOR IMPACTS OF BCDL

This section discusses two additional aspects of the labor impacts of BCDL. First, the changes in employee earnings discussed above following the adoption of BCDL do not capture all the employee-related costs to firms. They do not include the costs of employee fringe benefits or of training programs for new employees. In addition, estimates of earnings costs do not include costs of severance pay or income maintenance for discharged employees in the materials and container industries. For example, the contracts of the United Steel Workers with aluminum and steel producers call for extra unemployment benefits, special pensions for plant shutdowns, and other income security provisions. The Steel Workers also represent workers in can-manufacturing plants, and such severance benefits have been extended to that industry .(117) In the event of a layoff of employees both in metals and in metal can production, employees would be eligible for substantial financial assistance. This would aid affected workers but would be an added expense for firms.

A second important aspect of labor impacts is the fact that job losses in the glass container industry might be seriously localized. RCC has made a preliminary analysis of this problem and has identified 10 counties in the United States in which 14 glass container plants that might be especially hard hit by BCDL are located. (118) They were unable, however, to determine whether the manufacture of beverage containers is a large fraction of the production of each of these plants, in order to determine whether, in fact, special problems would be created. RCC is working with the Glass Packaging Institute to learn more about the situation in these plants.

POLICY OPTIONS FOR LABOR IMPACTS

On balance, the creation of more jobs and higher total earnings as a consequence of BCDL would contribute in a small way toward easing the Nation's unemployment problem. But, a very serious unemployment problem would be faced by workers in container manufacturing, and to a lesser extent, in the metals production industries. As noted in table 81, various studies have projected losses of 25,000 to 82,000 existing jobs due to BCDL. Since these jobs would be lost over a period of several years, some of them could be accounted for by normal attrition and retirement. Thus the number of workers now employed who might lose their jobs as a result of BCDL could be substantially smaller than 25,000 to 82,000. This might be especially true in metals production, where beverage-container related jobs are a small part of the total.

Nevertheless, while total employment would increase, a substantial number of workers with specialized skills would lose jobs, many in regions where unemployment is already high or economic growth is slow. Thus, if BCDL were instituted, some kind of Federal assistance for affected workers might be considered. Options include retraining and relocation assistance and direct grants-in-aid. Reconversion assistance to firms might also assist workers indirectly, but it cannot be viewed as a substitute for direct assistance to workers and their families. Such assistance efforts need to be designed and administered so that they would not provide incentives for firms to accelerate or expand their layoff programs. Furthermore, container firms have been routinely reducing their labor force over the last several years by taking advantage of new, more-productive technology. Thus, it might prove to be difficult for program administrators to determine whether layoffs can, in fact, be attributed to BCDL.

Impacts of BCDL on Beverage Costs and Prices

BCDL would cause increases in some costs of beverage delivery (filling, distribution, transportation, storage, retailing) and decreases in others (principally the cost of containers per fill). Various authors differ as to whether the net cost change is an increase or a decrease. They also differ as to whether prices paid by consumers would go up or down. This section reviews some of the analyses of changes in costs and prices, including some empirical observations on the relative prices of beverages in refillable and nonreturnable containers.

Unless otherwise noted, in this section as in the rest of this report, price refers to the shelf price of a beverage excluding any container deposit or local sales taxes. A purchaser of beverages in containers that bear a deposit, who does not intend to claim that deposit, pays a price equal to the shelf price plus the deposit.

REDUCED COSTS OF CONTAINERS UNDER BCDL

The beverage delivery system includes three parties for beer (brewer, distributor, and retailer) and two parties for soft drinks (bottler and retailer). For distributors and retailers, the direct costs of doing business are higher with beverages in refillables than in nonreturnables. Handling refillables entails a larger number of tasks, and the unit costs of most of the tasks are higher, because refillables weigh more and take up more space than nonreturnables. Sorting refillables adds an additional costly task.

Brewers and bottlers also face higher costs for washing, filling, and handling refillables than they do for nonreturnables. However, their costs for refillable containers per fill are less than the costs for nonreturnable containers. The costs of producing the beverage per se are not affected by packaging type. Thus, the net impact of BCDL on total costs for brewers and bottlers depends on the net of the various cost differences in buying and handling containers.

Typical prices paid by brewers in 1976 for new 12-ounce containers in large lots were: refillable bottles, 7 cents; nonreturnable bottles, 4 cents; and metal cans, 6 cents. (119) Typical prices paid by soft drink bottlers in late-1978 were about 17 cents for 16-ounce refillables, 8 to 9 cents for all-aluminum cans, and 8 cents for 3-piece steel cans with aluminum tops. (120) (These prices vary widely with container design, quantity purchased, and special sales arrangements). If a refillable is used an average of N times (N = trippage), its cost per fill is its price divided by N.

The total cost per fill of a container is reduced by its net scrap value if it is returned to the brewer or bottler under a deposit system.

Typically, as scrap, aluminum cans are worth 1 cent, steel cans are worth 0.2 to 0.4 cent, and bottles are worth about 1 cent each. If a deposit-bearing container is not returned, the brewer or bottler can retain its deposit as a cost offset. For an average return or recycle rate of R, the retained deposit per fill is equal to (l-R) multiplied by the deposit. For refillable bottles, the cost per fill is offset by both retained deposits and a very small scrap income from refillables rejected in the plant.

The following example compares the net costs of beverage containers per fill under three hypothetical situations:

Case I: A beverage is sold in 12-ounce nonreturnable containers that cost 8 cents each and do not carry a deposit. No containers are recycled.

Case II: A beverage is sold in 12-ounce, nonreturnable containers that cost 8 cents each, carry a 5-cent deposit, and have a scrap value of 1 cent each. Eighty percent of the containers are recycled.

Case III: A beverage is sold in 12-ounce refillable bottles that cost 12 cents each and carry a 5-cent deposit. The return rate for the container is 80 percent (trippage = 5).

Question: What is the net cost of the container per fill of beverage in each case?

Case 1: Container cost per fill = 8 cents.

Case II: Container cost per fill = 6.2 cents. Since for every container filled, 0.8 container is returned with a scrap value of 1 cent each, a scrap credit of 0.8 x 1 cent or 0.8 cent is earned per fill. For each container shipped a deposit of 5 cents is collected but on average only 0.8 container is recycled requiring an average refund of 0.8 x 5 cents or 4 cents per fill. Thus, 1 cent of the deposit per fill is retained by the producer. The direct container cost is then [8 cents – 0.8 cent – 1 cent] or 6.2 cents per fill.

Case 111: Container cost per fill = 1.4 cents. Since a bottle that costs 12 cents is used an average of 5 times, its cost per fill is 2.4 cents. Furthermore, for every container shipped a deposit of 5 cents is collected. However, on average only 0.8 container is returned, so an average of 20 percent of the deposit, or 1.0 cent is retained by the producer per fill. Therefore, the net direct container costs are (2.4 - 1.0) or 1.4 cents per fill.

In the above cases, the direct container costs per fill are 8 cents for the nonreturnable, 6.2 cents for the recycled nonreturnable with deposit, and 1.4 cents for the refillable. Thus, the refillable system will have the lowest total beverage delivery cost if the additional costs of handling refillable bottles as compared with nonreturnables are equal to or less than (8 cents – 1.4 cents) or 6.6 cents; and if the additional costs of handling refillable bottles as compared with recycled nonreturnables are equal to or less than (6.2 cents – 1.4 cents) or 4.8 cents. In other words, the production and distribution cost differential per fill with refillables over nonreturnables should not exceed 4.8 cents if BCDL is to result in lower total costs and prices. Conversely, if the extra costs of producing and distributing beverages in refillables are greater than 4.8 cents per fill, the total costs and the shelf prices of beverages can be expected to increase in this hypothetical example.

The container cost data and return/recycle rates used in this hypothetical comparison are intended to be reasonably representative of actual situations. They suggest that direct container costs are about 5 to 7 cents less for refillables than for nonreturnables. Only 0.5 cent of this cost advantage arises from retained deposits; the rest comes from differences in prices paid for containers per fill and from scrap income.

INCREASED COSTS OF BOTTLING BREWING, WHOLESALING, AND RETAILING UNDER BCDL

Data on the costs of brewing, bottling, wholesaling and retailing beverages in various kinds of containers, with or without BCDL, are scant. Weinberg (121,122) has given detailed accounts of these costs on a hypothetical basis for delivery of malt beverages. The Central Investment Corporation, which has interests in soft drink bottling, has provided data on the costs of bottling in 12-ounce cans and in 16-ounce refillable botties.(123) However, neither set of data is adequate for addressing the actual cost differences among the container types. Weinberg's data, for example, show that off-premise retailers' margins (costs plus profits) are lower for beer in refillables, but he gives no breakdown between costs and profits. Nor does he explain why these margins are lower for refillables in view of: (i) the wide agreement that retailers' costs are higher with refillables, and (ii) the fact that consumer prices are lower in refillables than in non-returnables. Also, no basis is given for his calculations of profits at each stage. (122)

PRICE IMPACTS OF BCDL

Models of Pricing Behavior.-The change in total costs of beverage production and delivery is the sum of: (i) savings on container purchase, (ii) earnings from the sale of recycled containers, and (iii) unclaimed deposits; less the sum of: (i) additional costs of capital including a reasonable return on investment, (ii) additional labor costs, and (iii) additional operating costs for maintenance, utilities, and insurance. The changes in prices of beer and soft drinks under BCDL would depend on the net change in the total cost of beverage delivery and on the degree to which that cost change would be passed on to consumers.

Whether cost changes would be passed on to consumers depends on the competitiveness of the various industries and on the degree to which consumer demand for beverages is affected by price and availability.

If the beverage industries are competitive, market forces will cause them to pass on changes in total beverage costs due to BCDL as changes in prices. The amount of the price change would depend on the sensitivity of beverage demand to price. If beverage demand is sensitive to price, firms would not be able to raise prices by the full amount of a cost increase. If there is a cost decrease they might take advantage of economies of scale in production and actually be able to lower prices by an amount greater than the decrease. * Conversely, if demand is not very sensitive to price, firms would pass on nearly the full amount of any cost change as a price change.

If some parts of the beverage delivery industries are not competitive, that is to say, if at least some firms or sectors possess a degree of monopoly power, a different set of price changes might take place. If BCDL were adopted, it is clear that brewers and bottlers (excluding distribution activities) would experience cost decreases, while wholesalers and retailers would experience operating cost increases. If brewers or bottlers have a degree of monopoly power, they would not be disciplined by market forces to pass their cost decreases on as lower prices for goods sold to wholesalers or retailers. Thus, the total costs of wholesalers and retailers would increase and they would raise prices to consumers, with the price increase being greater if consumer demand is not sensitive to price and vice versa.

Evidence was presented earlier in this chapter that the demand for beer is fairly price sensitive while the demand for soft drinks is not very price sensitive. The preceding theoretical discussion then leads to the following projections about the prices of each product if BCDL were adopted.

*The Wharton School study considered the effect of changes in beverage sales on container costs and prices, They found that the second-order price changes were very small .(1 24)

If the soft drink industry is competitive, any cost changes caused by BCDL would be passed on to consumers as price changes, either as increases or decreases depending on the net cost change. If the soft drink industry is not competitive to some degree, prices might increase under BCDL regardless of changes in the total costs of beverage delivery.

If the beer industry is competitive, cost changes caused by BCDL would be passed on to consumers, but prices would increase by less than a cost increase and might decline by more than a cost decrease (reflecting price sensitivity of demand and possible economies of scale). If the brewing industry possesses a degree of market power, retail prices to consumers might actually increase even if the total costs are reduced under BCDL; however, the increase would be less than the amount of distributor and retailer cost increases and smaller than in the case of soft drinks, since demand is more sensitive to price.

Unfortunately, it is not known for certain whether the beer and soft drink industries are competitive or possess a degree of market power. Thus, one cannot make reliable forecasts of the price effects of BCDL, even if unequivocal estimates of its effects on costs in each industry could be made. Part of the disagreement in the literature about the price effects of BCDL thus stems from a disagreement over the degree to which the industries are competitive.

Literature Forecasts of Beverage Prices Under BCDL.—TWO approaches have been used to forecast changes in future beverage shelf prices under BCDL. One is based on analytical cost/price models of the beverage industries. The other is based on extrapolations from the existing data on the relative prices of beverages in various kinds of containers and on the behavior of prices in Oregon and Vermont under BCDL.

Table 83 summarizes forecasts from the literature of changes in prices based on the analytical model approach. The figures from RTI and RCC suggest price changes in the range of –4.o to + 1.6 percent, depending on beverage, container type, and scenario. These estimates assume that retained deposits are used to offset increased costs. The Wharton School estimated increases of 3.1 percent for soft drinks and 4.7 or 13.1 percent for beer, depending on which type of beer bottle is used. These estimates are based on an all-refillable system and higher conversion costs than those of RTI and RCC. Furthermore, the Wharton School treated retained deposits as a direct consumer cost. When the shelf prices are adjusted to reflect the offset of a producer's costs by retained deposits, Wharton's shelf prices in the off-premise market increase by only 0.5 percent for soft drinks and 0.8 to 9.1 percent for beer. In all cases, of course, customers who discard deposit containers pay, in effect, 5 cents over shelf price (Wharton used a 6-cent deposit for soft drinks).

Evidence on Current Prices of Beverages.—Most reports of the relative prices of beverages in various types of containers have been based on informal price surveys. However, a comprehensive set of data gathered by the Majers Corporation provides information on feature prices* for soft drinks in 106 major U.S. retail markets. (129) For the 12 months ending November 1977, Majers reported the average feature prices for soft drinks shown in table 84. Table 84 shows that soft drinks in 16-ounce refillable bottles were priced 41 percent below 12-ounce cans and 33 percent below 16-ounce nonreturnable bottles on a price-per-ounce basis. Similar ratios hold for individual major brands and in specific marketing areas.

The results of several price surveys are summarized in the EPA Fourth Report. EPA summarized these surveys by concluding that savings are often in the range of 3 to 8 cents per 12 ounces of beverage in refillable containers.(lol) This is equivalent to a price dif-

*Feature prices are advertised prices in supermarkets, which often offer soft drinks in special promotional campaigns.

Table 83.—Beverage Shelf Prices Under BCDL: Summary of Literature Estimates Based on Analytical Methods

		Percent change in shelf price							
		Beer				Soft drinks			
		Bottles		Cans		Bottles		Cans	
Source	Scenario [a]	Ref.	N.R.	Alum.	Steel	Ref.	N.R.	Alum.	Steel
Department of Commerce (125) . .	All-reffillable bottles	Increase	—	—	—	Increase	—	—	—
Research Triangle Institute (126).	Scenario 1	– 0.05	–	– 1.9	+ 1.5	– 0.8	–	– 2.0	+ 1.6
	Scenario 2	– 0.05	–	– 3.9	-0.8	+ 0.7	—	– 4.0	– 0.8
Resource Conservation Committee (127)	Mix I	0.0	– 0.7	– 3.1	– 0.7	0.0	– 0.9	– 3.2	+ 0.8
	Mix II	0.0	+ 0.8	– 1.5	+ 0.8	0.0	+ 0.4	– 2.0	+ 0.8
Wharton School[b](l 28).	Export	+ 13.1	—	—	—	+ 3.1	—	—	—
	Stubby	+ 4.7	—	—	—	+ 3.1	—	—	—
Wharton School adjusted[c].	Export	+ 9.1	—	—	—	+ 0.5	—	—	—
	Stubby	+ 0.8	—	—	—	+ 0.5	—	—	—

a see table 63 for scenario details.
b Baseline prices were not provided. Percentage changes were estamated assuming 1974 baseline prices of $5.00 and $4.00 Per case for beer and Soft drinks in 12" oz containers respectively Off-premise prices are reflected In these changes
cOTA adjusted wharton,s shelf price increases by subtracting retained deposits as an offset against cost increases

Table 84.—Feature Prices of Soft Drinks in Various Container Types

Container size and type	Average price a (ounce)
1202 cans . . .	1.33-
1602 refillable bottles	0.78
1602 nonreturnable bottles. . .	1.16
32 OZ refillable bottles	0.73
3202 nonreturnable bottles.	1.13
6402 refillable bottles	0.90
6402 nonreturnable bottles. .	1.12

a for 12 months ending November 1977
SOURCE Majers Corporation (129)

ference per ounce of 0.25 to 0.67 cent which is consistent with Majers' findings of a 0.38 to 0.55 cent per ounce difference.

Weinberg's estimates for typical shelf prices for 12-ounce containers of beer in 1976 were: metal cans, 25.6 cents; nonreturnable bottles, 25.5 cents; and refillable bottles, 23.0 cents.(1 22) The price advantage of refillables of 2.5 cents per serving is equivalent to 0.2 cent per ounce; i.e., to the low end of the EPA estimate.

There is broad agreement, then, that the current shelf prices consumers pay for beverages in refillable bottles are lower than for nonreturnables, generally in the range of 2 to 8 cents lower per 12-ounce container. (This is equivalent to price differences of about 10 to 30 percent.)

However, there is some disagreement about whether this difference would persist if BCDL were implemented. For example, Weinberg has argued that refillables for beer are currently being subsidized by nonreturnables, and that wholesalers actually lose money on refillables. (122) If this is true, then current prices for refillables are too low to cover all their costs, and under BCDL their prices would have to increase. What is not clear from this argument is why this cross subsidy should persist, since by the same argument there is a strong incentive for wholesalers and retailers to raise the prices of allegedly unprofitable refillables, both to drive them out of the market and to earn some profit on those that might remain.

One factor that would tend to reduce shelf price differences for various container types as compared with the current situation, is that under BCDL industries would find it necessary to make rapid changes in their capital equipment. These changes would add to the average costs of beverage delivery, at least during the transition period. Prices of nonreturnables might increase if equipment is used at a lower capacity than before BCDL, and the cost of additional equipment to handle increased sales with refillables might add to their average prices.

Finally, from a long run point of view, it is argued that the competition among different types of bottles and cans has served to keep all container prices low. If the nonreturnable bottle or can were to disappear from the marketplace under BCDL this competition might be eroded, and all container prices might rise over a period of time. None of the analyses of price/cost behavior has taken this possibility into account, and there is probably no way to do so other than by making arbitrary assumptions about relative prices in the future.

Beverage Availability and Consumption

Opponents of BCDL say that it would reduce the availability of beverages to consumers. Some stores would discontinue beverage sales, the number of brands sold in various market areas would decline, and fewer vending machines would be used due to the difficulty of refunding deposits. The net effect would be a drop in beverage sales. Proponents of BCDL argue the opposite—that availability would improve, especially the availability of a variety of brands of both beer and soft drinks in refillable containers. Both sides agree that the number of available container sizes and designs would decrease. *

A related argument is made about the convenience aspects of beverage purchase and consumption under BCDL. Opponents, who equate convenience with the availability of nonreturnable containers without deposits, say it would decline. Proponents argue that BCDL does not eliminate nonreturnable containers and would not affect this aspect of convenience. They further argue that customers who value the convenience of discarding used containers can continue to do so; they would simply forfeit the deposit. Proponents also point out that refillables would become more convenient to purchase and that convenience of return would improve for those who prefer refillables or find it economically worthwhile to recover deposits.

Another related argument centers on the phrase "freedom of choice. " Opponents have used this phrase to suggest that BCDL would infringe on the rights of customers to purchase, use, and discard the containers of their choice in the manner of their own choosing. Proponents of BCDL argue that these choices would remain available to those who wish to exercise them, but that they should pay the costs associated with those choices through the deposit system. The "freedom of choice" argument is relevant in a discussion of a ban on nonreturnables. It does not apply to proposals for BCDL.

The consumption of beverages under BCDL would be affected by the change in shelf price, by the addition of the deposit on formerly nondeposit containers, and by a change in the availability of beverage brands, sales, and return outlets.

Some analysts have argued that consumption will be affected by the value that former consumers of nonreturnables attach to the time and effort required to make returns. If such customers are, in fact, rational, they will not make such returns if that value exceeds the potential 5-cent refund. Thus, the maximum decrease in purchases by these kinds of customers can be estimated by assuming that the price they would have to pay would be equal to the shelf price plus the deposit. On the other hand, sales to current purchasers of refillables might increase if the number and convenience of return points were to increase under BCDL.

An estimate of the impacts of price changes on consumption can be obtained by multiplying projected price changes from table 83 by the estimated price elasticities of demand. As noted in an earlier section, RTI

*The analysis in this chapter is concerned exclusively with containers for beer and soft drinks. However, the impact of BCDL on availability might be greatest for other beverages such as iced tea and mineral water. Since these are currently sold in much smaller volumes, the adoption of BCDL might make them unmarketable in many locations due to the relatively high overhead costs of operating a deposit system for small numbers of containers, On the other hand, omission of these beverages from BCDL coverage could lead to their rapid substitution for beer and soft drinks in the kinds of markets where the litter problem is most serious.

found price elasticities of demand of 0.6 for beer and 0.13 for soft drinks. Using & 2 percent as rough estimates of shelf price changes, one can estimate changes in beer sales of around & 1 percent, and around 0.25 percent for soft drinks.

The effective percentage price changes faced by customers who continue to discard deposit containers would be higher. A 5-cent deposit might add 25 percent to the effective price per container of soft drinks and 20 percent for beer. For these customers, maximum decreases in consumption might be expected of 20 percent x 0.6 or 12 percent for beer, and 25 percent x 0.13 or 3 percent for soft drinks.

RTI estimated that overall beverage demand would drop by only a fraction of 1 percent under BCDL.(130) For one of its calculations, the Wharton School assumed that beverage consumption would decline by 15 percent, based on their interpretation of events in Oregon and Vermont. (131) Using an elasticity of demand approach on the other hand, Wharton estimated maximum consumption decreases of 7.64 percent for beer and 4.43 percent for soft drinks, assuming that nonreturnable containers were banned. (132) The discrepancies originate in the different analyses of the price elasticity of beverage demand discussed earlier. Neither Wharton nor RTI was able to account for the quantitative effect of the availability/convenience argument.

Impacts on the Environment

Every stage of the production, use, reuse, and recycling of beverage containers creates air and water pollution and solid waste, over and above that due to disposal or littering. Such wastes are a function not only of container material, type, and return/recycle rate but also of the type and degree of environmental control technology employed at each stage. Furthermore, the true social cost of each kind of emission also depends on the location of the activity in question: air pollution may be more significant in a major urban area or near a pristine wilderness than in a small-town manufacturing center.

For these reasons, any estimation of the pollution impacts of various container systems is necessarily somewhat arbitrary. It usually reflects the current technology in place or to be adopted in the near term. It is also likely to reflect average industrial pollution control practice, rather than a "best-plant, " ''worst-plant, " "marginal plant, " or "compliance" practice. As such, the results of the analysis can be expected to change over time as industrial technology and pollution control methods change.

The standard reference work in this area is a study done for EPA by MRI in 1974 entitled "Resource and Environmental Profile Analysis of Nine Beverage Container Alternatives. ''(133) Environmental impacts were included for materials extraction and processing, container manufacture, transportation, container cleaning and filling, and distribution. Impacts of consumer activities including transportation from point-of-purchase to point-of-consumption were not included.

Table 85 summarizes the air and water pollution, industrial solid waste, and total water use impacts for the nine container systems studied by MRI. Each data point represents the impacts of delivering 1,000 gallons of beer in each type of container. In nearly every case the 19- and lo-trip refillable glass bottles rank lowest on these measures of environmental impact. The only major exception is the all-steel can, which ranks lowest on waterborne wastes. The five trip glass refillable (return rate = 80 percent) has a mixed advantage over the other containers. It ranks better than the others on industrial solid wastes and on atmospheric emissions (except for the all-steel can). It has the greatest amount of waterborne waste of any system (tied with ABS plastic) and is tied with several other systems in terms of total water use. From these data, it is concluded that a shift to a system featuring refillable bottles and recycled cans would reduce the environmental impact of beverage delivery.

Table 85.—Environmental Impacts of Delivering 1,000 Gallons of Beer in Various Containers

Container type	Air emissions (pounds)	Waterborne wastes (pounds)	Total water use (1 ,000 gallons)	Industrial sol id waste (cubic feet)
Glass refillable				
19 trip	71	27	11	7
10 trip	94	35	15	9
5 trip	200	69	33	
Glass nonreturnable	261	56	37	15
Three-piece bimetal	222	34	34	93
Aluminum can a	323	59	15	36
All steel can	146			108
Plastic coated nonreturnable glass	246	: :		30
Plastic b	241	69	42	7

a 15 percent of cans recycled
b Acrylonitrile- butaidiene-styrene (ABS) plastic Was used for illustration This material is not now. nor is it likely to be used for beverage containers. drink containers now on the market are made from polyethylene terephthalate (polyester)
SOURCE Midwest Research Institute (133)

These results have some important limitations. As noted above, they are based on actual industrial pollution control performance rather than on a best-practice basis. Perhaps more importantly, the air, water, and solid waste measures are in terms of total pounds of emissions. No attempt was made to rate the degree of hazard per pound of the waste components to public health or to the environment. Thus, fluoride emissions from aluminum production and oxides of nitrogen from gas combustion in glass production are compared on a weight basis, when, in fact, the former poses a considerably greater hazard than the latter.

In its recent report, RCC reported estimates of the impact of BCDL on industrial solid wastes, atmospheric emissions, and waterborne waste in 1985. As shown in table 86, substantial improvements are forecast under BCDL for all three waste categories. Waste loads are reduced by 44 to 52 percent under Mix I and by 69 to 86 percent under Mix II. These reductions occur because reusing and recycling containers create much less pollution than do extracting and processing materials to make new containers.

Health and Safety Impacts

BCDL might affect health and safety in such areas as pest and hazard control in unwashed, used containers; worker injury when handling returned glass containers and when carrying heavier glass refillables; and injuries due to glass litter and to bottle explosions and breakage. In principle, one could estimate these impacts for various scenarios under BCDL. Unfortunately, the necessary data are not generally available by container type.

HEALTH IMPACTS

Unwashed empty beer and soft drink containers are favorable environments for the growth of insects and vermin. However, observers of the long-established voluntary deposit system have not identified this as a major problem. Likewise, authorities in both Oregon (135) and Vermont (136) report that no special pest control problems have arisen in the programs of those States. The Vermont law allows a retailer to refuse to accept dirty containers for deposit, a provision that can help to manage potential sanitation problems.

Other types of container contamination such as gasoline, solvents, or solid materials can be a problem with refillable containers. Glass containers can be adequately washed, but plastics would absorb such foreign materials and be unacceptable for reuse or even for recycling into new food or beverage containers. Solid contaminants not removed by washing can be detected prior to refilling in bottle inspection systems. It is probable, however, that refillable containers pose a

Table 86.—Resource Conservation Committee Estimates of the Impact of BCDL on Industrial Pollution in 1985*

		Mix I		Mix II	
	Baseline	Total	reduction from baseline	Total	Reduction from baseline
Industrial solid wastes . . . . (million cubic feet)	524	250	52 "/0	71	860/0
Atmospheric emissions . . . . . . (mllllon pounds)	1,717	968	44%	521	700/o
Waterborne wastes. ... . (million pounds)	308	173	44°/0	94	690/0

'The numbers in this table represent industrial effluents from the extraction, fabrication, and recycling sectors of beverage container production See table 63 for definition of the market shares and return rates for Mix I and Mix II
SOURCE RCC staff estimates (134)

higher risk of product contamination—the extent of that risk is unknown.

FDA has jurisdiction over the health aspects of materials used for food packaging, including beverage containers, under the Food, Drug, and Cosmetic Act. In recent years, beverage containers made of certain plastics have become a matter of concern and policy debate.

On March 11, 1977', the Commissioner of FDA stayed certain parts of the food additive regulations that permitted beverage containers to be made of acrylonitrile copolymer plastics. This action had the effect of prohibiting the sale of such bottles. FDA's concern was that residual acrylonitrile monomer from the plastic container would migrate into the beverage with toxic effects. The Commissioner's order was appealed by Monsanto, the company that developed and began to market the bottle in 1975, and a Federal appeals court ruled that FDA had to undertake administrative proceedings on the safety of the bottle. In September 1977, FDA, after investigating its safety in public hearings and additional laboratory testing, issued a final order banning the use of beverage containers made from acrylonitrile-based plastics. Monsanto was given go days, to December 22, 1977, to remove the bottles from the market.(13g) The company has since filed an appeal of FDA's ban on the use of acrylonitrile copolymer in plastic soft drink bottles in the U.S. Court of Appeals in Washington, D.C.(138) A review of the case is expected in 1979. Monsanto has removed bottles made from acrylonitrile copolymer from the market, pending review by the U.S. Court.

The Bureau of Alcohol, Tobacco, and Firearms also regulates alcoholic beverage containers. In conjunction with FDA it licensed, and then terminated, an experiment to market alcoholic beverages in polyvinylchloride (PVC) containers after potentially hazardous levels of vinylchloride were found to have leached into the contents from the containers.(13g) While two companies soon developed bottles with monomer levels below 25 parts per million, authorization for their use was not granted and PVC liquor bottle development has ceased in the United States.

FDA has approved plastic beverage containers made from polyethylene terephthalate, a polyester. Several companies are using this polyester as a material for lightweight, energy-efficient, breakage-resistant containers. The bottles are being aggressively marketed by soft drink manufacturers in both 32- and 64-ounce sizes.

WORKER INJURY

No statistics are available on the nature, frequency, or severity of worker injury from different types of beverage containers. Heavier refillables may be associated with a higher incidence of skeletomuscular injuries in delivery and stock workers. However, it is likely that workers move more containers of nonreturnables at a time and thus the weight and consequent injury risk remain the same for both container types. Handling glass refillables might be more hazardous than handling cans. Furthermore, a refillable container will be handled more times per trip than a nonreturnable; which should increase the probability of injury per unit sold, even if the probability of injury is the same for each handling operation. However, data are not available to provide a basis for assessing the relative frequency of such injuries.

LITTER INJURY

Under BCDL, litter-related injuries due to broken glass on highways, city streets, and recreational areas should decline as the beverage container litter rate declines.

Studies of litter injuries have been made in California and Kentucky .(140,141) Both the California and Kentucky litter surveys indicated that the large majority of reported injuries were caused by broken glass and pull tabs. In California, approximately 25 percent of the persons interviewed reported that someone in their immediate family had been injured by litter, and 5.3 percent knew of someone who had swallowed, or almost swallowed, a pull tab they had put into a drink. Both the California and Kentucky studies on litter indicate that littered soft drink and beer containers, pull tabs, and plastic six-pack binders also cause injury to livestock and wildlife.

OTHER INJURY

Under BCDL the fraction and number of beverages sold in refillable glass bottles is likely to increase, while those in nonreturnable bottles would decrease. Under these conditions, it is not clear whether the consumer and worker injury rate due to broken or exploding beverage containers might increase or decrease. There are no data on the frequency of such events according to type of bottle.

The Consumer Product Safety Commission has jurisdiction over the safety of containers under the Consumer Product Safety Act. Injuries resulting from metal soft drink and beer cans, glass soft drink and beer bottles, and self-contained openers (pull-tops) are collected and categorized in the Commission’s National Electronic Injury Surveillance System. Information is gathered from a sample of hospital emergency rooms throughout the country in order to monitor the occurrence and seriousness of consumer product safety problems. From these data, estimates of the incidence of product-related injuries can be made for the entire United States.

The Commission categorizes injuries related to carbonated soft drink and beer containers into four classifications: Code 1103—self-contained openers, pop-top cans, zip-open cans, etc.: Code 1112—containers, metal (cans); Code 11 20—glass soft drink bottles for carbonated beverages; and Code 1122—glass containers, malt beverages (beer, ale, malt liquor). Analysis of data for 1974 by the Commission found that more than 32,000 persons were treated in hospital emergency rooms for injuries related to carbonated soft drink bottles. (142) These injuries occurred as a result of passive exploding bottles, bottles exploding on impact, propulsion of bottle caps, breakage resulting from impact, and accidental contact with broken glass. The available data does not differentiate between refillable and nonreturnable glass bottles.

The estimate for 1,377 is approximately 34,000 injuries related to glass soft drink bottles. Self-contained openers (pop-tops) caused around 2,200 injuries. Injuries resulting from glass beer and related containers were estimated at around 11,000.(143)

Manufacturers and distributors have taken steps to improve the quality of the production and handling of beverage bottles in order to reduce the risk of injury. In cooperation with the National Bureau of Standards, two voluntary product standards (VPS) are being developed. (144) One is completed and one is in the initial stage. The completed VPS recommends standards for the manufacturers of carbonated soft drink bottles, while the second VPS would establish guidelines for distributors of bottled carbonated soft drinks. The purpose of these standards is to reduce the number of injuries resulting from carbonated soft drink bottles. The standards are concerned only with refillable and nonreturnable glass bottles manufactured from soda-lime-silica glass. They are not applicable to plastic-clad or encapsulated bottles.

Impacts on New Technology

BCDL would provide a stimulus for development of new technologies in such areas as container materials, designs, and types; new beverages; and new delivery system elements including secondary packaging, vehicles, vending machines with capability to refund deposits, and container-sorting devices. One might also expect novel advertising and marketing techniques designed to take advantage of the new situation with minimum disruption.

The recent history of experience with Government regulatory programs suggests that industry is capable of adjusting to new market conditions with new or redesigned technologies, often at a lower cost than was projected prior to the implementation of such regulation. (145) Furthermore, when major technical advances are not required on short notice, firms can adjust best on their own. For this to happen, however, requires a stable, well-defined, and relatively certain business and regulatory environment. Firms from outside the established industries can sometimes take advantage of the new environment to provide innovative replacements for older technologies. Under these conditions, direct Government involvement in developing new technologies is not needed.

On the negative side, BCDL might establish a barrier to the private development and adoption of improved "standard" refillable containers that can be used by two or more bottlers or brewers for different brands. This would be an undesirable impact of BCDL, since refillable containers have not changed in recent years and they could be improved. Under BCDL the incentive for a firm to incur the costs of R&D to develop a better standard container would be weakened, because it could not take advantage of its competition through exclusive use of a lower cost container. The situation would be even worse if the new standard container were one that cost more to produce but that cost less to fill and distribute. In this case the innovator would be directly subsidizing his competitors if he were to distribute higher cost containers for general reuse. Because antitrust regulations would probably prevent firms from agreeing to develop new standard containers, the administrator of the BCDL program might be given authority to fund the necessary research, to set guidelines for standard container design, or to coordinate cooperative industry activity in this area.

Government Impacts

BCDL would affect Government by its requirements for administering the deposit program; by affecting tax revenues from beverage-related industries; and by reducing the costs of litter control, solid waste management, and materials and energy supply. The latter cost reductions were discussed earlier and will not be examined here.

Administrative costs of BCDL would be small. Fundamentally, BCDL uses a market mechanism rather than a regulatory approach. Unlike Government regulatory programs with respect to public health and the environment, BCDL requires no research, standards-setting, or monitoring programs, and enforcement would be limited to acting on violations reported by consumers or by other parties to the beverage transaction. Under BCDL, the increased trade in returned containers might lead to an increase in illegal activity, such as the fraudulent return for deposit of containers destined for recycling, which have already been returned. This problem is inherent in the fact that the refund value of a nonreturnable is 5 to 10 times its value for recycling. Some additional law enforcement effort might be required to deal with this problem.

Jeffords and Webster (146) report that Government administrative costs for the first 5 years of the Vermont law totaled between $1,000 and $1,500. Most of this expense was for duplication of the law and for advertising to notify the public of proposed regulations. Given the nature of Federal programs, and in view of the likelihood of numerous legal challenges to Federal BCDL, it is unrealistic to expect that this $200 to $300 per year cost could be extrapolated to the national level. Nevertheless, the Vermont experience suggests that administrative costs would not be large.

Under BCDL certain Federal, State, and local tax revenues might be affected. Federal and State excise taxes on beer would change in proportion to sales changes. State and local sales taxes on beer and soft drinks would change in proportion to sales as well. Local property tax revenues might increase as total plant investment increases. Corporate income taxes might decline substantially from the can and bottle industries and increase from the beverage production and delivery industries. Personal income taxes on the higher total earnings would probably increase, although the shift to lower average wages paid would tend to offset some of this increase.

Estimates of Government revenue change are sensitive to several parameters whose values are not well established, such as sales, prices, investment, and wages. In their study of a ban on nonreturnables, the Wharton School estimated increases in total Government revenues of $273 million to $472 million. (147) Corporate and personal income taxes accounted for most of the increase, with corporate tax increases about twice as large as those for personal income taxes. Sales tax increases were only about 10 percent of the total. Property tax changes were not examined. It is likely that these estimates are on the high side, since the Wharton study features the greatest increase in investment and employment of any of the major analyses.

Emerging Influences on Beverage Container Choice

The analysis of BCDL in this chapter uses a number of assumptions that are based on a continuation of historic trends in the structure of the beverage industries and in beverage container technology. This section discusses two emerging trends that may heavily influence the performance of the beverage delivery system for soft drinks: the plastic softdrink container and the recent Federal Trade Commission (FTC) decision regarding territorial franchises for soft drinks.

The Plastic Soft Drink Bottle

Recently, plastic soft drink bottles manufactured from a polyester (polyethylene terephthalate or PET) have made very rapid gains in market share in the large 1- and 2-liter sizes (approximately 1 and 2 quarts). First marketed in 1976, PET bottles appear to have gained about one-fourth of the market for 2-liter containers by 1978.*(148) The National Soft Drink Association reports that I.5- to 2-liter containers held 6.3 percent of the total market in 1977, up from 2.5 percent in 1974. Securities analysts are projecting rapid penetration of plastics into soft drink markets in the next few years. (137, 148) At least four major firms now produce PET beverage containers.(149)

In an earlier venture, Monsanto had introduced a beverage container based on a polyacrylonitrile resin that was ordered off the market by FDA on health grounds. (See earlier section on health and safety aspects of containers). PET has not encountered any health- or safety-related problems.

*Authoritative data on plastic containers for soft drinks are not yet available in standard industry or Government sources. Most of such data now come from business and trade publications, All of the plastic beverage containers currently in use are intended to be nonreturnable. In principle, a plastic container could be made refillable. However, this would require much heavier container construction, which would defeat their major advantage—light weight. Furthermore, plastics are liable to partial degradation under heat and light and can absorb foreign substances, such as solvents or fuels, that might be stored in empties. These characteristics make refilling plastic bottles a doubtful possibility. For these reasons, if plastic bottles are returned for deposit under BCDL, they are more likely to be recycled into noncontainer plastic articles than to be reused or made into new beverage bottles.

On first consideration, nonreturnable plastic containers made from oil and natural gas would seem to be very energy intensive. However, plastics are so much lighter than glass and require so much less energy for production than do aluminum or steel that the nonreturnable 2-liter PET bottle uses less energy per ounce of soft drink delivered than any other container but the refillable glass bottle. (150) The PET system also uses less natural gas than any alternative except refillable glass, but it uses more petroleum than any container-type except aluminum cans and nonreturnable glass. When compared to a 2-liter plastic-coated glass bottle, the 2-liter PET bottle uses considerably less total energy, including much less natural gas and about the same amount of petroleum.

Should the plastic container displace significant numbers of cans or glass bottles in smaller sizes (10 to 16 ounces), it could have more serious negative consequences for current container producers than would BCDL. They would sustain a loss in both production volume and jobs. In fact, the projected negative consequences of BCDL for the industries and workers now producing containers may occur as a result of the use of plastic bottles, regardless of whether BCDL is adopted. In any future analyses of the effectiveness and impacts of the possible adoption of BCDL the role of the plastic bottle must be given serious consideration.

The FTC Decision on Soft Drink Territorial Franchises

BACKGROUND OF THE DECISION

On April 7, 1978, FTC ordered the Coca-Cola Company and others, and PepsiCo to cease and desist from enforcing contracts that allocate or restrict the territories of franchised bottlers. (151) It ordered the end of all such marketing agreements, except for beverages in refillable containers which can continue to be sold in restricted territories under exclusive franchises. The FTC's orders in these cases have been appealed in the U.S. Court of Appeals in Washington, D. C., and a decision of the Court is pending. (152)

Some opponents of the FTC decision, arguing in part by analogy to the evolution of the beer industry since World War II, say that if the FTC decision is upheld, small bottlers will be driven out of the market. (153) National companies that operate from large, high-speed regional plants using nonreturnable containers will be responsible for the rapid demise of the refillable bottle under these circumstances. According to this view, the exclusive franchise agreements protect the refillable container.

The contrary point of view is that the franchise system has protected small bottlers who are operating with technology that fails to take advantage of the enhanced productivity of larger, more modern equipment. Furthermore, it is argued that franchise bottlers are not disciplined by intrabrand market forces to compete on the grounds of price, quality, or service. According to this view, consumers are injured by the franchise system, and the fact that refillables are maintained by it is evidence of the use of inefficient technology by franchisees.

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INTERACTION OF BCDL AND THE FTC DECISION

It is not the purpose of this study to examine the legal arguments regarding the FTC decision and the status of the territorial franchise system. * However, it is useful to examine how the decision, if it stands, would interact with or affect BCDL.

First, if passed, BCDL could help reduce any trend to regional bottling stimulated by the FTC decision. By helping to preserve the role of the refillable in the marketplace, BCDL would undercut the economic advantage of centralized bottling, which is limited to nonreturnable containers. (The heavier weight of refillables and the need to back haul empties discourages their centralized bottling.) Thus, BCDL might slow any trend toward elimination of local bottlers.

Second, BCDL could continue to discourage litter, reduce solid waste, and reduce the use of virgin materials, regardless of whether territorial franchises stand. The deposits under BCDL would continue to provide an incentive to return all containers for recycling and/or reuse rather than to litter them or put them in the trash.

Third, the energy use for soft drink delivery would be lower under BCDL if the FTC decision is upheld, than if it stands without BCDL. In a recent study, Franklin Associates has shown that assuming the FTC decision causes a rapid decline in the use of refillables for soft drinks, energy use for the delivery of soft drinks in 1982 could range from 17 to 36 percent higher than if the decision is overturned and BCDL is not passed. (154) BCDL would help preserve the refillable bottle and lessen the impact of the FTC decision on energy use. The quantitative effect, however, has not been estimated.

*Several bills have been introduced in the 96th Congress that would permit the maintenance of the territorial franchise system for carbonated soft drinks by exempting soft drinks from the antitrust laws for this purpose. See, for example, H.R, 596, 1512, 1669, 1693, and 1868 and S. 268 and 598.

Finally, it is noteworthy that both the beer and soft drink industries are complex, and are characterized by a mix of small and large firms, regional and national markets, and extensive use of packaging alternatives as marketing and competitive devices.(155 to 158] None of the major analyses of the effects of BCDL assessed in this chapter has taken these structural complexities into account. In part, this reflects the limits of the art of policy analysis. But, it also contributes to the inherent uncertainty regarding the ultimate outcomes of either BCDL or antitrust action taken against the industries.

Findings on BCDL

During the past 30 years, the beer and soft drink industries have shifted heavily from sales in refillable glass bottles to the use of nonreturnable glass bottles and metal cans. At the same time, the sales of both beverages in individual packages have grown dramatically. One result of these trends has been that discarded beverage containers have become important parts both of litter and of MSW. Beverage delivery has become more energy- and materials-intensive, while employing fewer people and using less capital per unit delivered. Economies of scale in brewing, bottling, and transportation, especially in lightweight nonreturnables, have favored a trend toward the centralization of bottling and brewing with fewer producers and fewer brands available. Packaging has become an important part of beverage marketing strategy, with a wide variety of package sizes and types available.

Legislation has been proposed whose purpose is to slow the declining market share of beverages in refillable bottles by imposing a mandatory, uniform, refundable deposit on each individual container. Beverage container deposit legislation, or BCDL, would not ban any type of container—can or bottle. Unlike a ban on nonreturnable containers, this legislation would preserve the right of producers and consumers to use the package of their choice. Moreover, it would ensure that users of nonreturnables pay the full cost of their disposal, and would provide incentives for recycling and against littering.

Considerable uncertainty exists regarding the ultimate effects of BCDL on container market shares and on return and recycle rates. No one has devised a method for predicting these outcomes, which depend on market decisions by consumers and on the exercise of at least limited market power by producers and distributors. Nevertheless, experience in the several States that have implemented BCDL, as well as the judgments of informed observers, indicate that BCDL would lead to a greater use of refillable bottles and to higher rates of container return for reuse and recycling.

A review of seven major and several minor studies of BCDL sponsored by proponents, opponents, and neutral parties finds them all in agreement that BCDL would accomplish all of its major goals to some degree. It would lead to a reduction in litter, in MSW, and in consumption of energy and raw materials. It would also serve as a symbol of a commitment to resource conservation, even though it would not save as much energy or materials as such measures as energy efficiency standards for buildings and automobiles.

BCDL would have a number of important side effects that are not intended by its proponents and which should be considered. It would increase the capital needs of brewers, bottlers, wholesalers, and retailers. At the same time, it would severely disrupt the metal can and glass bottle industries. Overall employment in beverage delivery would increase, along with total compensation to workers in the affected industries. However, existing skilled jobs would be lost in materials and container production, while relatively unskilled jobs would be gained in wholesaling, transportation, and retailing of beverages.

Under BCDL, the costs of containers per fill would decline due to the enhanced use of multitrip refillables, while other costs of delivery might increase. Available data do not permit a consensus judgment of the net effect of BCDL on total costs, nor on the shelf prices of beer and soft drinks. Some authors project a decrease in costs and prices, others an increase. Data on current prices show that beverages are cheaper in refillables, but there is some reason to believe that this might not be the case under BCDL.

The availability of beverages in refillable containers is expected to improve under BCDL, whereas the number of types of containers might decline. Depending on how consumers value the convenience of refillables and nonreturnables, as well as on the uncertain price changes, beverage consumption might decline by at most a few percent under BCDL.

Refillable containers generally cause less air and water pollution and less industrial solid wastes than other container types on a per-fill basis. Litter-related injury from improperly discarded glass bottles would probably decline under BCDL. It is not possible to say with the data currently available whether injuries to workers and consumers would increase or decrease. No evidence was found that refillable glass bottles pose additional health or sanitation hazards.

If BCDL were passed, new technology is expected to emerge for managing refillable containers and for recycling nonreturnables. Government action might be needed to spur development of new, more efficient standard refillable containers for use industrywide.

BCDL would cause some shift in tax revenues at and among the local, State, and Federal levels because it would change the mix of capital, labor, and incomes for the beverage-related industries and for their employees. While BCDL uses the market approach to regulation and is nearly self-administering, some additional Government resources would be needed to administer and police a deposit system.

The growing popularity of the plastic bottle could drastically alter the soft drink package mix, whether or not BCDL is adopted. If made available in smaller sizes (10 to 16 ounces), plastic containers would markedly alter the projections of system performance, effectiveness, and impacts under BCDL that are discussed in this chapter. If upheld by the courts and not amended by the Congress, the recent FTC decision, which outlaws territorial franchise restrictions for trademarked soft drinks in nonreturnable containers, could lead to rapid concentration of that industry. The outcomes would be an industry with only a few firms having a few large plants, as well as the rapid disappearance of the refillable bottle for soft drinks. BCDL could help retard or limit these consequences.

References

1. "Materials Conservation Through Reduced Wastage," U.S. Office of Technology Assessment, forthcoming.
2. Committee Findings and *Staff* Papers on National Beverage Container Deposits, Second Report of the Resource Conservation Committee, January 1978, p. 2
3. Keep America Beautiful, Inc., 1978 *Annual* Review, New York, N. Y., Nov. 30, 1978.
4. Keep America Beautiful, Inc., *Final* Report Action Research *Model*, New York, N. Y., Dec. 3, 1975.
5. Keep Amercia Beautiful, Inc., *Clean* Community System Bulletin, March 1979, p. 3.
6. Litter Control, Recycling and Resource Recovery Act of 1977, Chapter 1161, California Statutes, 1977.
7. Information supplied by Earl Tower, Project Director, Model Litter Control Act, Washington State Department of Ecology, May 1978.
8. California State Senate Bill No. 373 amending the Revenue and Taxation Code. Approved by the Governor, Feb. 27, 1979.
9. The Society *of* the Plastics Industry, Inc. v. The City *of New* York, N.Y. State Supreme Court, Sept. 16, 1971.
10. Ward, Penny, "Deadly Throwaways—Plastic Six-Pack Binders and Metal Pull Tabs Doom Wildlife," *Defenders of Wildlife*, June 1975.
11. Resource Conservation Committee, op. cit.
12. Braden, P. L., S. R. Rideout, and J. H. Leigh, An Evaluation *of* Deposit-Return Systems *for* the Michigan Beer Market, Report for the U.S. Brewers Association by the Graduate School of Business Administration, The University of Michigan, August 1977.
13. Oregon's *Bottle Bill:* The 1977 Report, State of Oregon, Department of Environmental Quality, March 1977.
14. Young, W. R., and N. Silverstein, "A Hard Look at the Plastic Soft Drink Bottle: A Bubbly Future?," Morgan Stanley and Co., Institutional Research, July 29, 1977.
15. Glass Packaging Institute, *Annual* Report, Washington, D. C., 1977.
16. Can Manufacturers Institute, *Metal* Cans Shipment Report, 2976, and Year to Date *Metal* Cans Shipments Report, Apr. 7, 1978.
17. U.S. Bureau of Mines, Mineral Commodity Summaries, 1978, p. 4, 84.
18. Data for 1947-73 from Brewers Almanac as reported in reference 20, p. A-7. Data for 1975-77 personal communication, Phillip Katz, U.S. Brewers Association, May 1978.
19. Data for 1947-73 from Statistical *Profile* 1973, National Soft Drink Association as reported in reference 20, p. A-11. Data for 1974-76 from Statistical *Profile* 1976, National Soft Drink Association. Data for 1977, personal communication, Kenneth A. Doyle, National Soft Drink Association.
20. Bingham, Taylor H., et al., Energy and Economic impacts *of* Mandatory Deposits, Research Triangle Institute, Research Triangle Park, North Carolina, for Federal Energy Administration, September 1976. Available as NTIS, PB-258-638. Appendix A.
21. Robert S. Weinberg and Associates, "The Effects of Convenience Packaging on the Malt Beverage Industry, 1947-1969, " prepared for the U.S. Brewers Association, Inc., Dec. 1, 1971, p. 4.
22. R. S. Weinberg and Associates as reported in reference 21, p. A-7.
23. Data for 1947-73 from Robert S. Weinberg and Associates as reported in reference 20, p. B-5. Data for 1975-77, personal communication, Phillip Katz, U.S. Brewers Association, May 1978.
24. Data from 1947-73 from NSDA Statistical *Profile* as reported in reference 20, p. B-n. Data for 1974-77 personal communication, Kenneth Doyle, NSDA, May 1978.

25. Riley, John J., A History *of the* American *Soft* Drink Industry, American Bottlers of Carbonated Beverages, Washington, D. C., 1958. (Reprinted by Arno Press, New York, N. Y., 1972) p. 206, 207.
26. American Can Company, "A History of Packaged Beer and Its Market in the United States, " 1969, p. 7.
27. Riley, op. cit., p. 272.
28. Bingham, et al., op. cit., p. 23.
29. American Can, op. cit., p. 9.
30. American Can, op. cit., p. 8.
31. Riley, op. cit., p. 271.
32. Data for 1954-73 from NSDA Statistical *Profile* as reported in reference 20, p. B-11. Data for 1974-75 from NSDA Statistical *Profile* 1976. Data for 1975-76 from NSDA *Sales* Survey *of the Soft* Drink Industry. Data for 1976-77, personal communication, Kenneth Doyle, NSDA, May 1978.
33. American Can, op. cit., p. 113.
34. Bureau of Alcohol, Tobacco and Firearms, U.S. Department of the Treasury, Breweries Authorized to Operate, July 1978.
35. Denver Post, Aug. 8, 1977, p. 28.
36. Riley, op. cit., p. 275.
37. NSDA, Statistical *Profile* 1976.
38. Lamer, Robert, "The Economics of Territorial Restrictions in the Soft Drink Industry, " Antitrust Bulletin, 22, 147 (Spring 1977).
39. Bingham, et al., op. cit., p. B-28, B29.
40. R. S. Weinberg and Associates, op. cit., chart 14.
41. General Accounting Office, Potential *Effects of* A National Mandatory Deposit *on* Beverage Containers, report no. PAD-78-19, Dec. 7, 1977, p. 13.
42. Organization for Economic Cooperation and Development, Environment Directorate, *Re-Use* and Recycling *of* Packaging Materials-Beverage Containers Case Study, draft final report, report Env/MPW/77.2, Paris, France, January 1977, p. 111.
43, U.S. Department of Agriculture, Food Stamp Program Regulations, title 7, chapter 11, subchapter C, part 272.2(b), June 30, 1976.
44. Montz, Dwight, U.S. Department of Agriculture, personal communication, Jan. 24, 1978.
45. Syrek, Daniel B., *California* Litter: A Comprehensive Analysis and Plan *for* Abatement, Institute for Applied Research, Carmichael, Calif., May 1975.
46. Tawil, Jack J., *Social* Costs *of* Beverage Containers: An Economic Analysis *of* Six Legislative Solutions *for* Maryland, Maryland Department of Economic and Community Development, Annapolis, Md., Mar. 12, 1976, p. 8.
47. Nelson, John P., J. N. Williams, Jr., T. H. Reynolds, H, The *Impact of* Litter, Research Report No. 127, Commonwealth of Kentucky Legislative Research Commission, Frankfort, Ky., October 1975, p. 8.
48. Nelson, op. cit., p. 19.
49. Syrek, Daniel B., Litter Reduction *Effectiveness, Volume* Two, Washington's Litter Control Program and Oregon's Container Deposit Legislation, Report by the Institute for Applied Research, Sacramento, Calif., to the Continental Can Company, November 1977. p. 2.
50. Environmental Protection Agency, Resource Recovery and Waste Reduction, Fourth *Report* to Congress, EPA-SW-600, August 1977, p, 69.
51. Statistical Abstract *of* the United States, 93rd Edition, 1972, p. 538.
52. Binkley, Clark, and James F. Hudson, *Litter:* Cost, Measurement and Control, draft report by Urban Systems Research and Engineering, Inc., Cambridge, Mass., to EPA, June 1977.
53. Jeffords, James M., and D. W. Webster, "Vermont 5 cents Deposit, " November 1977, p. 10. Available from office of Congressman Jeffords.
54. Waggoner, Don, "Oregon's Bottle Bill Two Years Later," Oregon Environmental Council, 1974, p. 10.
55. Ackoff, Russell L., et al., A Study *of* the

Impacts on the *USA* of a Ban on One-Way Beverage Containers, prepared for the U.S. Brewers Association by Busch Center, the Wharton School, University of Pennsylvania, Philadelphia, Pa., December 1976, vol. I, app. E, p. 61.
56. GAO, op. cit., pp. 22-26.
57. GAO, op. cit., p. 26.
58. Resource Conservation Committee, op. cit., p. 40.
59. Binkley and Hudson, op. cit., p. 40.
60. Bureau of Domestic Commerce Staff, The Impacts of National Beverage Container Legislation. U.S. Department of Commerce, staff study a-01-75, October 1975.
61. Environmental Protection Agency, op. cit.
62. General Accounting Office, op. cit.
63. Hannon, Bruce, "System Energy and Recycling: A Study of the Beverage Industry," report number 23, Center for Advanced Computation, University of Illinois, Urbana-Champaign, Mar. 17, 1973.
64. Bingham, Taylor H., et al., op. cit.
65. Resource Conservation Committee, op. cit.
66. Ackoff, Russell L., et al., op. cit.
67. Ackoff, et al., op. cit., vol. II, p. 34.
68. Bingham, et al., op. cit., pp. D-58, D-84, D-1 13.
69. Ackoff, et al., op. cit., vol. II, pp. 64, 128, (see footnote table 64).
70. EPA, op. cit., p. 70.
71. Personal communication, Kenneth Doyle, National Soft Drink Association, May 1978.
72. Personal communication, Phillip Katz, U.S. Brewers Association, May 1978.
73. Ernst & Ernst, for Can Manufacturers Institute, Apr. 7, 1978.
74. Ackoff, et al., op. cit., vol. II, p. 2.
75. GAO, op. cit., p. 14.
76. Bingham, et al., op. cit., pp. 28, 30.
77. Bureau of Domestic Commerce Staff, op. cit., p. 4.
78. Ackoff, et al., op. cit., vol. II, pp. 9, 10.
79. Midwest Research Institute, Resource and Environmental *Profile* Analysis of Nine Beverage Container Alternatives, report for the Environmental Protection Agency, EPA-350-SW-91C, 1974, p. 9.
80. GAO, op. cit., p. 30.
81. Battelle Columbus Division, Evaluation of Energy Consumed in Using Refillable *Glass* Bottles and Cans for Beer and Soft Drinks, report to Can Manufacturers Institute, June 1978.
82. Bureau of Domestic Commerce Staff, op. cit., p. 3.
83. GAO, op. cit., p. 28.
84. Bingham, et al., op. cit., p. 3.
85. Resource Conservation Committee, op. cit., p. 43.
86. Ackoff, et al., op. cit., vol. II, p. 11.
87. Bingham, et al., op. cit., p. D-3.
88. Ackoff, et al., op. cit., p. 12.
89. Bingham, et al., op. cit., p. 34.
90. Battelle Columbus Division, op. cit., p. v.
91. Robert S. Weinberg and Associates, letter to H. B. King, U.S. Brewers Association, reviewing RTI/FEA study, Energy and Economic Impacts of Mandatory Deposits, Nov. 28, 1975, p. 13.
92. Bureau of Domestic Commerce staff, op. cit., p. 18.
93. GAO, op. cit., p. 26, 27.
94. Bingham, et al., op. cit., p. I-5, I-6.
95. Resource Conservation Committee, op. cit., p. 41.
96. EPA, Resource Recovery and Waste Reduction, op. cit., pp. 17, 18.
97. Bingham, et al., op. cit., p. 36.
98. Robert S. Weinberg and Associates, letter to H. B. King, op. cit., p. 3.
99. Ackoff, et al., op. cit., app. A, p. A-9. The questionnaires and results are appended to ref. 98.
100. Bureau of Domestic Commerce Staff, op. cit., p. 14.
101. EPA, op. cit., p. 73.
102. Bingham, et al., op. cit., p. 59.
103. GAO op. cit., p. 58.
104. Ackoff, et al., op. cit., p. 29.
105. White, D. Lamar, GAO, personal communication to C. T. Hill, July 25, 1978.
106, Statement of Amory B. Lovins before Joint Hearings of the Select Committee on Small Business and the Committee on

Interior and Insular Affairs, U.S. Senate, Dec. 9, 1976.
107. Bingham, et al., op. cit., p. 40.
108. Bureau of Domestic Commerce Staff, op. cit., pp. 2, 3.
109, EPA, op. cit., p. 71.
110. GAO, op. cit., pp. 40,65.
111. Bingham, et al., op. cit., p. 65.
112. Resource Conservation Committee, op. cit., p. 38,
113. Ackoff, et al., op. cit., p. 37.
114. EPA, op. cit., p. 72.
115. GAO, op. cit., p. 33.
116. Bingham, et al., op. cit., p. 68.
117. Oshinski, John L., United Steelworkers of America, personal communication, May 1978. Also, "A Hard Line on Lifetime Security, " Business Week, Oct. 31, 1977, p. 33.
1184 Resource Conservation Committee, op. cit., p. 88.
119. Robert S. Weinberg and Associates, "The Impact of a Shift From the Present Convenience Packaging Malt Beverage Production Distribution System to a Returnable Bottles-Only System on the Price the Consumer will Ultimately Have to Pay for Malt Beverages for Off-Premise Consumption, " prepared for the U.S. Brewers Association, Inc., Oct. 15, 1976, p. 7.
120. Confidential industry data.
121. Robert S. Weinberg and Associates, Papers 1, 7, and 8 in *Reference* Source *Book*, U.S. Brewers Association, Washington, D. C., January 1978.
122. Weinberg, Robert S., "The Economics of the Malt Beverage Production/Distribution System 1976, " Working paper appended to a memorandum for the U.S. Brewers Association critiquing the June 1978 Final Draft OTA report, Aug. 8, 1978.
123. Central Investment Corp., Cincinnati, Ohio, "Cost of Goods," Aug. 31, 1978.
124, Ackoff, et al., op. cit., pp. 46-48.
125. Bureau of Domestic Commerce Staff, op. cit., p. 4.
126. Bingham, et al., op. cit., p. 50.
127. Resource Conservation Committee, op. cit., p. 36.
128. Ackoff, et al., op. cit., p. 43 footnote.
129. Majers Market Research Company, "Carbonated Soft Drinks. 12 Months Ending November 1977.'' Omaha, Nebr.
130, Bingham, et al., op. cit., p. 51.
131. Ackoff, et al., op. cit., p. 24.
132, Letter to A. E. Paladino, OTA, from Arthur Finnel, The Wharton School, Aug. 7, 1978, p. 2.
133. Midwest Research Institute, op. cit., p. 21.
134. Resource Conservation Committee, op. cit., p. 42.
135. "Oregon's Bottle Bill: The 1977 Report, " op. cit., p. 5.
136. Jeffords and Webster, op. cit., p. 1.
137. Young, William R. and Naomi Silverstein, op. cit.
138. "Fighting Bottle Ban," Chemical Week, Nov. 23, 1977, p. 19.
139. U.S. Department of the Treasury, Bureau of Alcohol, Tobacco, and Firearms, "Alcohol, Tobacco and Firearms' Industry Circular 73-10,'' May 1973.
140. Syrek, Daniel B., *California* Litter: A Comprehensive Analysis and *Plan for* Abatement, op. cit., pp. 59-72.
141. Nelson, John P., John N. Williams, Jr., and Thurston Howard Reynolds, II, op. cit., pp. 1-8.
142. U.S. Consumer Product Safety Commission, Bureau of Epidemiology, "Hazard Analysis: Bottles for Carbonated Soft Drinks," NIIC-111O-75-HOO4, April 1975.
143. Based on data provided by Nancy Johnston, Director, National Injury Information Clearinghouse, Hazard Identification and Analysis, U.S. Consumer Product Safety Commission, May 1978.
144. Chaffee, David, "Bottle Safety Now the Subject of Two Voluntary Standards," Dimensions/NBS, February 1978, p. 17.
145. Ashford, Nicholas A., and George R. Heaton, "The Effects of Health and Environmental Regulation on Technological Change in the Chemical Industry: Theory

and Evidence, " in Federal Regulation and Chemical Innovation, Christopher T. Hill, editor, American Chemical Society Symposium Series, no. 109, 1979.
146. Jeffords and Webster, op. cit., p. 31.
147, Ackoff, et al., op. cit., p. 63.
148, Marcial, Gene G.,' 'Inroads by Plastics in the Container Market Make Analysts Wary on Glass, Metal Stocks, " *Wall* Street Journal, July 17, 1978.
149. Chemical Week, July 26, 1978, p. 37.
150. Franklin Associates, Lt'd., "Energy and Environmental Impacts Associated With A Federal Trade Commission Decision, " report to R. G. Gay, Attorney at Law, Feb. 14, 1979, p. 22.
151. Docket No. 8855, U.S. Federal Trade Commission, *Final* Order and Opinion, in the Matter *of* the Coca-Cola Company (*and* others), Apr. 7, 1978. Also Docket No. 8856, *In* the Matter *of* Pepsico, Inc.
152. The Coca-Cola Company *et al.* v. The Federal Trade Commission, U.S. Court of Appeals (Docket No. 78-1364).
153. The Pepsi-Cola Bottling Companies of Canton, Ohio, Mansfield, Ohio, Ft. Lauderdale, Fla., and West Palm Beach, Fla., Competition in the *Soft* Drink Industry and How *It Really* Affects the Consumer, November 1978.
154. Franklin Associates, op. cit., p. 4.
155. Keithahn, Charles F., The Brewing Industry, Staff Report of the Federal Trade Commission, December 1978.
156. Fraundorf, Kenneth, C., The *Social* Costs of Packaging Competition in the Beer and Soft Drink Industries, Ph. D. dissertation, Cornell University, Ithaca, N. Y., 1971.
157. Hatten, Kenneth J., and Dan E. Schendel, "Heterogeneity Within An Industry: Firm Conduct in the U.S. Brewing Industry, 1952 -71," *J.* Industrial Economics, XXVI, 97-113 (December 1977).
158. "The Battle of the Beers, " Newsweek, Sept. 4, 1978.

Appendixes

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Selected Federal Laws Related to Resource Recovery, Recycling, and Reuse

The Federal Solid Waste Disposal Act of 1965, as Amended by the Resource Recovery Act of 1970

The Solid Waste Disposal Act of 1965 was passed as part of the Clean Air Act amendments of 1965 (Public Law 89-272, 79 Stat. 992 (1965)). * This legislation emphasized the Federal Government's awareness of the growing problem of solid waste disposal and the interrelationship of solid waste disposal with air pollution, generation rates, etc. It should also be noted that along with congressional awareness of the relationship between waste disposal and air pollution was a concern with the problems of inadequate space for landfills, and the increasing costs of waste disposal. As a result of such problems, the Solid Waste Disposal Act of 1965 was amended by the Resource Recovery Act of 1970, which not only stressed new methods of solid waste disposal, but emphasized the importance of recycling and reuse of waste materials (Public Law 91-512, 84 Stat. 1227 (1970)).

The purposes of the 1965 Act, as expanded by the 1970 Amendments, were to design and test solid waste management and resource recovery systems that would preserve and enhance the quality of water, air, and land resources. Also, the 1965 Act provided technical and financial assistance to State governments and interstate agencies in planning and developing solid waste disposal and resource recovery programs. The Act also emphasized the need to improve management techniques and organizational arrangements for collecting, separating, recovering, and recycling solid wastes and for disposing of unrecoverable residues.

The 1965 Act was administered originally by the Department of Health, Education, and Welfare. In 1970, the Environmental Protection Agency (EPA) was given jurisdiction over the Act due to a reorganization in the executive branch. The major responsibilities mandated for the EPA Administrator in administering the 1965 Act are as follows.

- To conduct studies and give financial aid to government and private agencies and institutions, as well as to individuals, to undertake research, training, demonstration, and studies regarding the effects of solid waste on the environment.
- Make studies of the operation and financing of solid waste disposal programs and of ways of reducing the amount of such waste and unsalvageable waste materials.
- Studies should also concern themselves with the development of new or improved methods of collection and disposal and with new methods of processing and recovery of materials and energy from solid wastes.
- Results of all studies supported financially by the Government should be made available to the public.
- Any patents, information, or processes developed during any federally supported programs or R&D must be made

*The relationship between clean air and solid waste disposal is obvious: waste incineration, poorly managed landfills, and open dumping and burning can contribute to air pollution. While the Clean Air Act is very complex and covers many sources of pollution, the discussion in this report will be limited to those aspects of the Act that pertain to the disposal of solid wastes.

available on fair and equitable terms to industries whose activities relate to solid waste disposal.

- Grants or contracts may be provided to public or private agencies and institutions and to individuals for research, training projects, surveys and demonstrations, including the construction of facilities, which are involved in work related to solid waste disposal.
- Examine the following study areas:
  1. Changes in product characteristics, packaging and production practices which would reduce the amount of solid waste generation;
  2. Methods of collection, separation, and containerization, which might encourage efficient utilization of facilities and contribute to more effective progress on reduction, reuse, or disposal of wastes;
  3. Economic incentives, including Federal grants, loans, or other assistance which might increase the reclamation and recycling of materials from solid wastes;
  4. Existing public policies, including subsidies and economic incentives as well as disincentives, that have an effect on the recycling or reuse of materials; and
  5. Examination of the disposal charge or other charges if placed on packaging, containers, vehicles, and other manufactured goods.
- Report to Congress and to the President at least once a year on the results of the studies and investigations in this area carried out by the agencies.
- Demonstration projects may also be carried out by the Administrator in order to test methods and techniques. Results are to be made available to industry.
- Grants may be made by the Administrator to aid in State, interstate, and local planning. The law encourages regional, intermunicipal, and interstate planning efforts. The extent to which this type of planning was incorporated into a specific plan determined the amount of Federal funds.
- Recommend guidelines for solid waste recovery, collection, separation, and disposal systems. These guidelines are to be consistent with public health and welfare, air and water quality standards, and compatible with land use plans. These guidelines can be updated if necessary.

Title II of the Resource Recovery Act of 1970 (Public Law 91-512, 84 Stat. 1227), the Materials Policy Act of 1970, added an amendment to the 1965 Act that called for the Administrator of EPA to submit to Congress, no later than 2 years after enactment of the Resource Recovery Act of 1970, a report and plan creating a system of "national disposal sites for the storage and disposal of hazardous wastes, including radioactive, toxic, chemical, biologic, and otherwise" which may endanger public health or welfare. The plan was to include other data such as costs of operating and maintaining such sites.

The overall intent of both Acts, as explicitly expressed in the legislative findings of the 1970 Act (Resource Recovery Act of 1970, title II, 202, 84 Stat. 1234), was to enhance the quality of the environment and conserve materials through the development of a national materials policy. Such a policy would utilize the present resources and technology more efficiently and would help to anticipate future materials requirements plus make recommendations on materials use, recovery, and, of course, disposal.

The Resource Conservation and Recovery Act of 1976

a e of the major bills passed during the 94th Congress was the Resource Conservation and Recovery Act of 1976 (Public Law 94-580, 90 Stat. 2795), which establishes broad new programs to help combat the Nation's growing solid waste problems. In summary, the law sets up comprehensive hazardous waste regulations, provides incentives for better waste planning, and accelerates solid waste research, development, and demonstration.

It is divided into four major sections. The first section simply states the title in full, the "Resource Conservation and Recovery Act of 1976. " Section 2 states that the Act amends the Solid Waste Disposal Act of 1965. This section, which will be discussed below, contains eight subtitles that define the provisions of the amendments. Section 3 states that a study should be conducted to determine the best procedures for removing solid waste on Federal lands in Alaska. And, section 4 specifies that in order to demonstrate effective means of dealing with contamination of public water supplies by leachate from abandoned or other landfills, EPA is authorized to provide technical and financial assistance for a research program at the Llangollen Landfill in New Castle County, Del.

As stated above the substance of the Act is contained in section 2, which has eight subtitles as follows:

Subtitle A, General Provisions. This subtitle includes sections on findings, objectives, and definitions. It also contains provisions for congressional approval of interstate compacts, integration with other laws, and financial disclosure by EPA employees.

Section 1008 of the subtitle gives EPA 1 year to publish guidelines describing the level of performance that can be attained by various available solid waste management practices which protect the public health and environment. Further guidelines would be required within 2 years, along with minimum criteria for use by States to define open dumping.

Subtitle B, Authorities of the Administrator. Section 2001 establishes within EPA an Office of Solid Waste to be headed by a Deputy Assistant Administrator of EPA. This Office would carry out the Administrator's responsibilities as mandated by the Act. Section 2002 lists the authorities of the Administrator under the Act, and states that such regulations promulgated under the Act shall be reviewed at least every 3 years.

Section 2003 states that EPA shall provide teams of personnel, including Federal, State, and local employees or contractors (referred to as "Resource Conservation and Recovery Panels") to provide State and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation.

Section 2004 provides $750,000 in each of FY 1978-79 for 5-percent grants toward purchase of auto tire shredders, with private firms given the first opportunity to obtain grants.

Section 2005 states that EPA shall provide to Congress an annual report which will provide legislative recommendations regarding solid waste management, resource recovery, and resource conservation.

Section 2006 authorizes $35 million in FY 1977, $38 million in FY 1978, and $42 million in FY 1979 to administer the Act. Of the total, 20 percent must be used to fund the Resource Conservation and Recovery Panels, and 30 percent must be used to administer hazardous waste management provisions.

Subtitle C, Hazardous Waste Management. Section 3001 gives EPA 18 months to promulgate criteria for identifying hazardous wastes and list those wastes which should be regulated. States may petition EPA to add a specific waste to the list. Also 18 months after enactment, EPA must promulgate standards governing generators (sec. 3002), transporters, and owners/operators of treatment, storage, and disposal facilities (sec. 3004).

Under section 3005, EPA is given 18 months to promulgate regulations requiring treatment, storage, or disposal facilities to hold a permit issued by EPA or an authorized State program. Guidelines to help develop State programs must be promulgated within 18 months as specified by section 3006.

Section 3007 authorizes Federal and State inspection of facilities and records, and makes certain information publicly available.

Federal enforcement through compliance orders or civil action, after 30-day notices of violation are issued, are specified under section 3008. Section 3009 provides that no State or local government may impose less stringent hazardous waste management regulations.

Section 3010 requires existing generators, transporters, and facility operators to inform EPA or authorized States of their operations within 90 days of promulgation of section 3001 requirements. Section 3011 authorizes $25 million in each of FY 1978 and FY 1979 for grants to help States develop and implement hazardous waste programs, to be awarded when needed.

Subtitle D, State or Regional Solid Waste Plans. Section 4002 gives EPA 6 months to publish guidelines for identifying areas with common solid waste problems and 18 months to publish guidelines to aid in developing State plans. Section 4003 requires that the State plans ban new open dumps and close or upgrade existing ones. EPA would have 1 year after enactment of the Act to publish criteria for defining open dumps and sanitary landfills, with the ban on open dumps to take effect 6 months later or upon approval of State plans.

Section 4005 gives EPA 1 year after promulgating its criteria to inventory all disposal facilities classified as open dumps. Governors are given 6 months after promulgation of section 4002 guidelines to identify regional planning areas (sec. 4006). Section 4007 provides for approval of State plans by EPA, entitling States to receive Federal funds. And, section 4009 specifies that $25 million in both FY 1978 and FY 1979 should be spent to assist rural communities.

Subtitle E, Duties of the Secretary of Commerce. This subtitle encourages the Secretary to encourage greater commercialization of proven resource recovery technology by publishing guidelines for the development of specifications for recovered materials within 2 years (sec. 5002). The Secretary of Commerce is authorized within 2 years to identify the geographical location of existing or potential markets for recovered materials; identify economic and technical barriers to the use of recovered materials; and encourage the development of new uses for recovered materials. Also under section 5004, the Secretary is authorized to evaluate the commercial feasibility of resource recovery facilities and to publish the results of such evaluation.

Subtitle F, Federal Responsibilities. This subtitle states that all Federal installations must comply with all State and local laws. Also under section 6002 the Act ensures that the Federal procurement of recovered materials be maximized. The remainder of the subtitle requires that the Federal agencies cooperate with EPA and adhere to EPA guidelines (sees. 6003 and 6004).

Subtitle G, Miscellaneous Provisions. This subtitle covers employee protection, citizen suits, petition for public participation and regulations, labor standards, etc.

Subtitle H, Research, Development, Demonstration and Information. Section 8001 describes EPA's responsibilities and authorities for research, development, and demonstration and establishes a management program to insure cooperation of all RD&D activities. Section 8002 specifies areas that EPA should study: composition of waste stream, small-scale and low technology, front-end source separation, mining wastes, resource recovery facilities, sludge, and tires.

Section 8004 states that EPA may enter into contracts with public agencies or authorities or private persons for the construction and operation of a full-scale demonstration facility. EPA is authorized to award grants to any State, municipal, or interstate or intermunicipal agency for the demonstration of resource recovery systems or for the construction of new or improved solid waste disposal facilities.

Section 8007 authorizes EPA $35 million for FY 1978 to fund all the above sections except section 8002 which included its own funding of $8 million to finance specific studies.

The Federal Ocean Dumping Act

Along with the enactment of the Federal Water Pollution Control Act Amendments of 1972, came the passage by Congress of the Marine Protection, Research, and Sanctuaries Act of 1972, commonly known as the "Federal Ocean Dumping Act" (Public Law 92-532, 86 Stat. 1051, as amended Public Law 93-254,88 Stat. 50 (1974)).

While the general intent of the law is the international protection of the oceans, the specific discussion of municipal solid waste disposal is not irrelevant.

The law prohibits the dumping of any radiological, chemical, or biological warfare agents, or any high-level radioactive wastes. The dumping of other types of wastes is prohibited also, but it maybe authorized if a permit is administered under the law. Permits to dump materials including solid waste, may be issued by the EPA Administrator after notice and an opportunity for public hearings. Also before such permits may be issued, the Administrator must develop criteria by which such permits, or exceptions, may be granted. The criteria must include the need for such dumping, effects of dumping on health, recreational activities, fishing resources, etc. Also in devising criteria other options for disposing of material must be considered. The permits must designate the type and amount of material to be dumped, the specific period when dumping is allowed, and monitoring or surveillance specifications for dumping, and any regulations that might apply to the transportation of material to be dumped.

The major effect of the law has been to almost eliminate disposal of domestic solid wastes in the ocean.

The Energy Tax Act

The Energy Tax Act (Public Law 95-618, 92 Stat. 3174) contains two provisions that should influence recycling. One provides an additional 10-percent investment tax credit (for a total of 20 percent] for the purchase of equipment used to recycle ferrous (with certain exceptions) and nonferrous metals, textiles, paper, rubber, and other materials for energy conservation. The additional credit is available for a wide range of equipment placed in service after October 1, 1978. The other provision sets recycling targets for major energy-consuming industries. These include the metals, paper, textile, and rubber industries. Specific targets will be set for the increased use of recycled commodities over the next 10 years.

The Emergency Interim Consumer Product Safety Standard Act of 1978

The Emergency Interim Consumer Product Safety Standard Act of 1978 (Public Law 95-319, 92 Stat. 386) establishes an interim consumer product safety rule relating to the standards for flame resistance and corrosiveness of cellulosic home insulation. Cellulose insulation is made from recycled newspaper treated with fire retardant. The intent of the Act was to guard against fire hazards from insulation treated with inadequate amounts of fire retardants.

The legislation authorizes the Consumer Product Safety Commission to enforce the General Services Administration's (GSA) cellulose insulation safety standards (O-25 flame spread rating for cellulose insulation to be used in homes) until the Commission develops permanent standards. GSA standards previously applied only to Federal buildings. In addition, the Act includes language to expedite both changes in standards in the future and judicial review of standards.

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Legislative Activity in the 95th Congress Related to Resource Recovery, Recycling, and Reuse

During the 95th Congress a number of bills were introduced that gave consideration to resource recovery, recycling, and reuse. This appendix discusses key features of those that were not passed. (See chapter 2 and appendix A for discussions of those that became law.) The bills discussed in this appendix are identified in table RI.

Materials Policy

Two bills introduced during the 95th Congress would establish a materials policy for the United States by creating a materials research and development capability. These bills would encourage private industry to develop low-cost products and processes to promote the efficient use and reuse of materials; to minimize processing costs; to minimize the energy required for the processing, fabrication, and recycling of materials; and to reduce the dissipation through waste or pollution of useful materials with particular attention to those that are irreplaceable or scarce. H.R. 34 introduced by Representative Teague on January 4, 1977, and H.R. 10859, introduced by Representative Thornton with one cosponsor on February 8, 1978, are similar pieces of legislation. These were both entitled the "National Materials Policy, Research, and Organization Act. "

Hearings were held on national materials policy by the House Science and Technology Committee, Subcommittee on Science, Research, and Technology, during July 1977 with emphasis on H.R. 34, and during March 1978 with emphasis on H.R. 10859. Hearings were also held by the Senate Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space, in July 1977 on the general subject of national materials policy.

On February 28, 1978, Representative Hollenbeck and one cosponsor introduced H.R. 11203, the "National Materials Technology Research and Policy Planning Act of 1978." It was introduced as a follow-on bill designed to "place the research and development promoted by H.R. 10859 within the context of long-range planning and policymaking for the production, distribution, and consumption of materials, including fuels. " Like H.R. 10859 and H.R. 34, one goal of H.R. 11203 is to promote the efficient use and reuse of materials.

Beverage Container Deposits

A number of bills that would establish mandatory, nationwide, minimum beverage container deposits were introduced during the 95th Congress. On January 4, 1977, Representative Jeffords introduced two identical bills, H.R. 936, with 24 cosponsors, and H.R. 937, with 3 cosponsors, which would require refund values for certain beverage containers. These bills were reintroduced by Mr. Jeffords as H.R. 5582, H.R. 7155, H.R. 7886, H.R. 8788, H.R. 10047, and H.R. 13393, bringing the number of cosponsors in the House of Representatives to around 62 members. In addition, an identical bill, H.R. 8856, was introduced in the House of Representatives by

Table B-1 .—Bills Related to Resource Recovery, Recycling, and Reuse Introduced But Not Passed During the 95th Congress

Bill identification	Identification number House	Identification number Senate	Sponsor	D	Status as of November 1978
To establish a materials policy for the U. S., to create a materials research and development capability, and to provide an organizational structure.	H.R. 34		Teague (Tex.)	1/4/77	Referred to Committee. Hearings held.
To provide additional assistance to ERDA for advancement of nonnuclear energy research, development, and demonstration, including biomass conversion.	H.R. 36		Teague (Tex.)	1/4/77	Referred to Committee No further action.
To provide loan guarantees through ERDA for biomass demonstration facilities.	H.R. 37	—	Teague (Tex.)	1/4/77	Referred to Committee. No further action.
To ban interstate sale of nonreturnable beverage containers.	H.R. 873	—	Fish (N. Y.)	1/4/77	Referred to Committee. No further action.
To require refund values for certain beverage containers.	H.R. 936	—	Jeffords (Vt.)	1/4/77	Referred to Committee.
	H.R. 937		"	1/4/77	
	H.R. 5582			3/24/77	
	H.R. 7155		"	5/12177	
	H.R. 7886		"	6/20177	
	H.R. 8788	—	"	8/4/177	
	H.R. 10047	—	"	1 114/77	
	H.R. 13393	—	"	7/1O/78	
	—	S. 276	Hatfield (Ore.)	1118177	Referred to Committee. Hearing held.
	H.R. 8856	—	Ichord (Me.)	8/5/77	Referred to Commitee.
To amend the Internal Revenue Code of 1954 to provide reasonable and necessary income tax incentives to encourage the utilization of recycled solid waste materials and to offset income tax advantages which promote depletion of virgin natural resources.	H.R. 1077	—	Murphy (N. Y.)	1/4/77	Referred to Committee.
	H.R. 2772	—	Broomfield (Miss.)	2/1/77	No further action.
To Drovide technical and financial assistance for the development of management plans and facilities for the recovery of energy and other resources from discarded materials.	H.R. 1214	—	Roe (N. J.)	1/4/77	Referred to Committee. No further action.
To establish a program to provide assistance to local governments for solid waste disposal programs.	H.R. 10009	—	Patterson (Calif.)	11/3/77	Referred to Committee.
	H.R. 10887	—		2/9/78	No further action.
To establish a materials policy for the U. S., to create a materials research and development capability, and to provide an organizational structure. (Revision of H.R. 34.)	H.R. 10859	—	Thornton (Ark.)	2/8/78	Referred to Committee. Hearings held.
To provide context of long-range planning and policymaking for production, distribution, and consumption of materials, including fuels. Follow-on to H.R. 10859.	H.R. 11203	—	Hollenbeck (N. J.)	2/28/78	Referred to Committee.
Section 8 of bill would provide for study and investigation of all materials relating to the proper role of Government in encouraging the recycling of solid waste materials.	—	s. 17	McIntyre (N. H.)	1/10/77	Referred to Committee. No further action.

Congressman Ichord on August 5, 1977. A companion bill, S. 276, requiring a refund value for certain beverage containers, was introduced in the Senate by Senator Mark Hatfield and nine cosponsors on January 18, 1977.

All of the above mentioned bills were referred to as the "Beverage Container Reuse and Recycling Act of 1977." Hearings were held on S. 276 by the Senate Committee on Commerce, Science, and Transportation, Subcommittee on Consumer Affairs, in January 1978. Testimony was received from Members of both the House of Representatives and the Senate along with representatives of industry, labor, environmental groups, State and local governments, and the executive branch.

In addition, hearings were held in August 1978 by the House Committee on Interstate and Foreign Commerce, Subcommittee on Transportation and Commerce, to review several governmental and private studies on mandatory beverage container deposits. These hearings did not focus on any particular bill but rather gathered information on the issue.

Ban Nonreturnable Beverage Containers

H.R. 873, introduced by Representative Fish on January 4, 1977, would ban the interstate sale of nonreturnable beverage containers. The bill's stated purpose is to reduce pollution caused by litter composed of soft drink and beer containers, and to eliminate the threat posed by such containers to the Nation's health, safety, and welfare.

Tax Incentives for Recycling Waste Products

Two bills would provide tax incentives for recycling waste products. Both H.R. 1077, introduced by Representative Murphy on January 4, 1977, and H.R. 2772, introduced by Representative Broomfield on February 1, 1977, would amend the Internal Revenue Code of 1954 to provide reasonable and necessary tax incentives to encourage utilizing recycled solid waste materials and to offset existing income tax advantages that promote depletion of virgin natural resources. Both bills were referred to the House Ways and Means Committee where no further action was taken.

On January 10, 1977, Senator McIntyre and two cosponsors introduced S. 17, which would amend the Internal Revenue Code of 1954 to provide income tax incentives for the conservation of energy used to heat or cool residences and commercial buildings and for the utilization of renewable fuel energy sources. Specifically section 8 of the bill would provide for a thorough and complete study and investigation of all materials relating to the proper role of the Government in encouraging the recycling of solid waste materials. This bill, entitled the "Renewable Energy and Energy Conservation Tax Act of 1977," was referred to the Senate Committee on Finance where no further action was taken.

Energy Recovery

Several bills would provide assistance to the Department of Energy (DOE) for energy recovery. H.R. 36, introduced by Representative Teague on January 4, 1977, would provide additional assistance to DOE for the advancement of nonnuclear energy research, development, and demonstration, including biomass conversion. Teague also introduced H.R. 37 on January 4, 1977, which would provide loan guarantees through DOE for biomass demonstration facilities not to exceed a total outstanding indebtedness of $300 million. No action was taken on either bill.

H,R. 1214, introduced on January 4, 1977, by Representative Roe, would provide technical and financial assistance for the development of management plans and facilities for the recovery of energy and other resources from discarded materials. This bill was referred to the House Interstate and Foreign Commerce Committee.

Solid Waste Product Charge System

Two identical bills introduced by Representative Patterson, H.R. 10009 on November 3, 1977, and H.R. 10887 on February 9, 1978, with five cosponsors, would establish a program to provide assistance to local governments for solid waste disposal. The purpose of the bills is to establish a national solid waste product charge system that would: (i) alleviate the financial burden that the rapid increase in solid waste management costs have imposed on local government; (ii) provide incentives for the establishment of markets for materials recovered from solid waste; (iii) internalize the costs of collecting, transporting, and disposing of materials by producers and consumers; and (iv) provide adequate time for producers and consumers to adjust their production and consumption practices. The charge would be placed on the sale or transfer at the bulk production level of rigid containers, flexible packaging, and all paper products with the exception of building, construction, and industrial grades, The initial base charge would include a charge of 1,3 cents per pound of paper and flexible packaging ($26 per ton) and a charge of 0,5 cent per container for rigid containers ($5 per thousand containers). The charge would be implemented over a 10-year period and would be revised periodically to reflect changes in solid waste management costs.

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Description of Resource Recovery Technologies

In this appendix, the processes for centralized resource recovery are described and the major unit processes of the technologies are identified. Although many processes recover both energy and materials, the technologies for each of these purposes are discussed separately here. A list of additional readings on resource recovery is included.

This appendix is primarily descriptive. It is based on published literature and on conversations with industry, Government, and other experts. Not all of the processes described here are in commercial use. See chapter 5 for a discussion of the status of the technologies and chapter 3 for a discussion of marketing of recovered materials and energy.

Energy Recovery Systems

Mass Incineration Processes

WATERWALL INCINERATION

In waterwall incineration, raw municipal solid waste (MSW) is burned directly in large waterwall furnaces, generally without preprocessing the waste. The primary product is steam, which can be used directly or converted to electric power, hot water, or chilled water. Figure C-1 shows schematically the main features of a waterwall furnace for unprocessed MSW.

In some installations shredding to reduce waste size and/or facilitate recovery of materials takes place. For example, at the Saugus, Mass. plant, large bulky items have been shredded before burning. (The shredder is being removed, however.) At Hamilton, Ontario MSW is shredded before burning. Ferrous metal can be recovered by magnetic separation from ash after incineration, or before incineration if MSW is pre-shredded.

Waterwall combustion systems nave been used commercially in Western Europe since World War II. Data from a recent survey of their experience indicate that European plants tend to achieve large scale using several small modular furnaces. For example, the 634 tons per day (tpd)* Sorain Cecchini facility in Rome, Italy has six, 4.4-ton-per-hour units.(2)

This modular approach contrasts with U.S. practice. The Saugus plant has a design capacity of around 1,500 tpd and uses two European Von Roll furnaces with a capacity of around 31 tons per hour each.

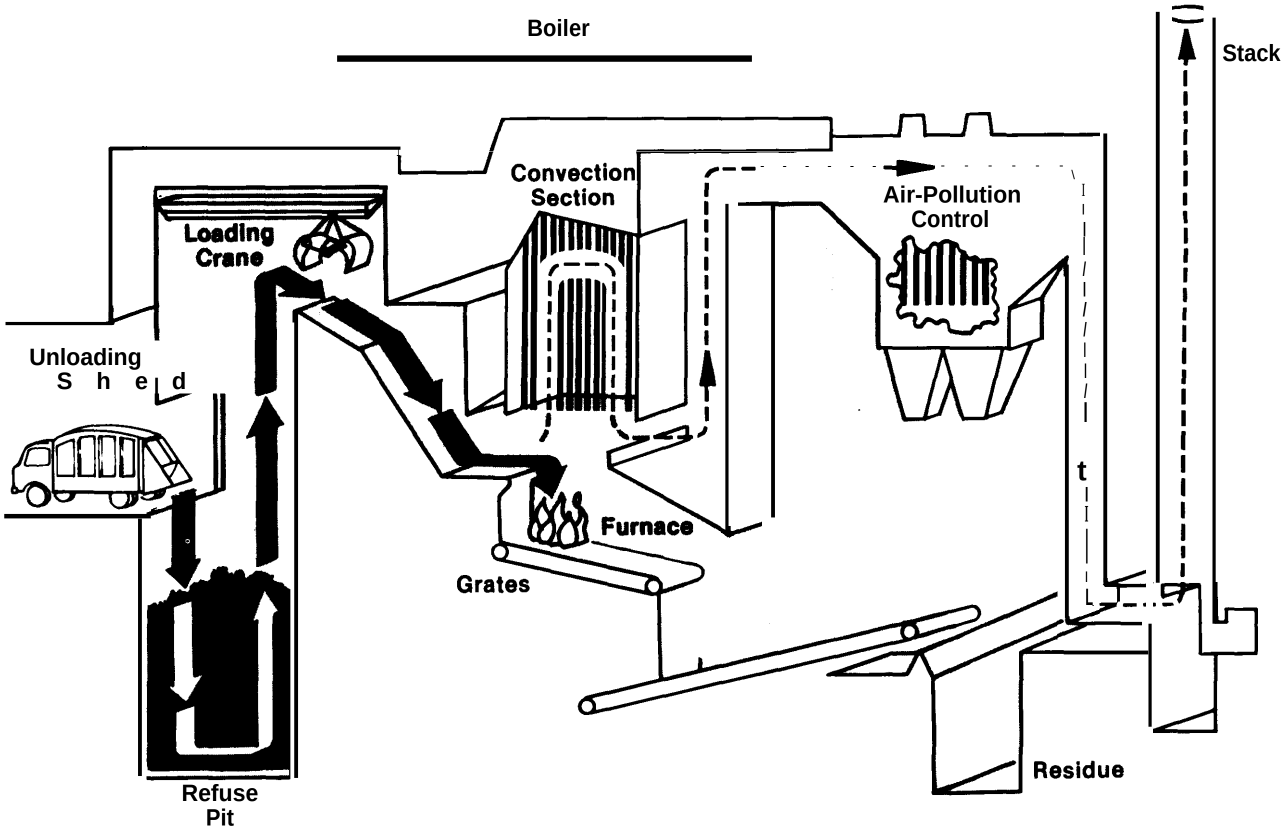
Even though European societies differ from ours, comparisons should be helpful in contemplating future technological directions for U.S. development. The Environmental Protection Agency (EPA) has an intensive, detailed study of European systems underway.

SMALL-SCALE MODULAR INCINERATION

Small-scale modular incinerators feature heat recovery as steam or hot water, and usually forego materials recovery. Most applications to date have been in hospitals, schools, other institutions, and industry whose wastes are more homogeneous than MSW. Thus, application of this technology to MSW is a relatively recent development. Three of these systems were reported as operational in EPA's Fourth Report to the

*All ton units in this appendix are short tons—2,000 pounds.

Figure C-1.—Typical Waterwall Furnace for Unprocessed Solid Waste



Congress: a 50-tpd unit at Blytheville, Ark., a 30-tpd unit at Groveton, N.H. and a 20-tpd facility at Siloam Springs, Ark.(3)

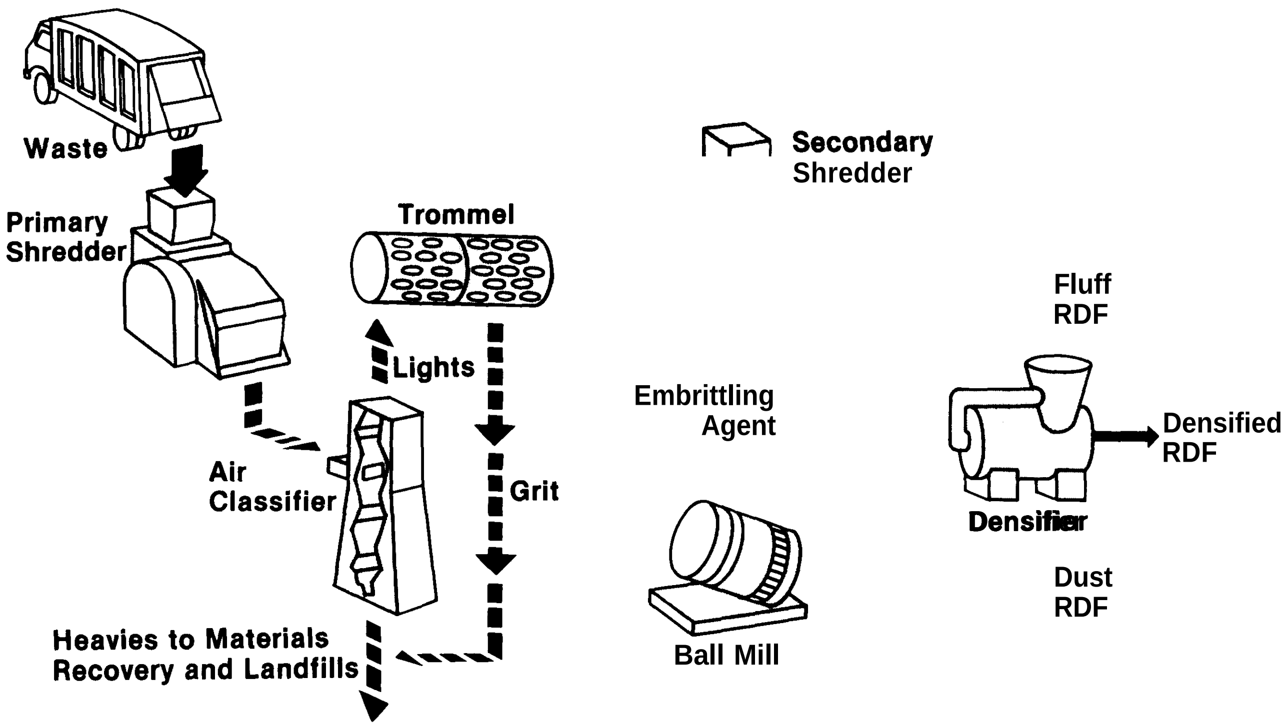
These systems are called modular because individual furnaces are small and desired plant size is achieved by installing several identical units or modules.(4) MSW is incinerated in two stages. First, raw MSW is burned in insufficient air to achieve complete combustion, producing a combustible gas and a byproduct residue. The gas from primary combustion is then burned with an auxiliary fuel [oil or gas) in a secondary combustion chamber with excess air. Hot gases from the secondary combustion chamber are passed through a waste heat recovery boiler or heat exchanger to produce steam, hot water, or hot air. The two-stage combustion process, as contrasted to traditional single-stage incineration, helps to reduce particulate emission problems.

Refuse-Derived Fuel Systems

Solid refuse-derived fuel (RDF) is produced by separating MSW and mechanically removing the organic combustible fraction using wet or dry processes. The fuel product of dry processing can be fluff RDF, densified RDF, or dust or powdered RDF depending on the subsequent processing used. Most RDF plants also recover one or more of the following materials; ferrous, aluminum, glass, or mixed nonferrous metals. Figure C-2 schematically portrays the main processes for producing the different RDF fuels.

In dry mechanical processing of the type used in the St. Louis, Me.; Ames, Iowa; and Washington, D.C. facilities, raw waste typically is first shredded to 8 inches or less in size. This shredded material is next put through a device called an "air classifier" that separates the light organic material from

Figure C-2.–This Simplified Flow Diagram Shows How the Dry Processing Approach (No Water Slurry) Can Be Used to Produce Fluff, Densified, or Dust RDF



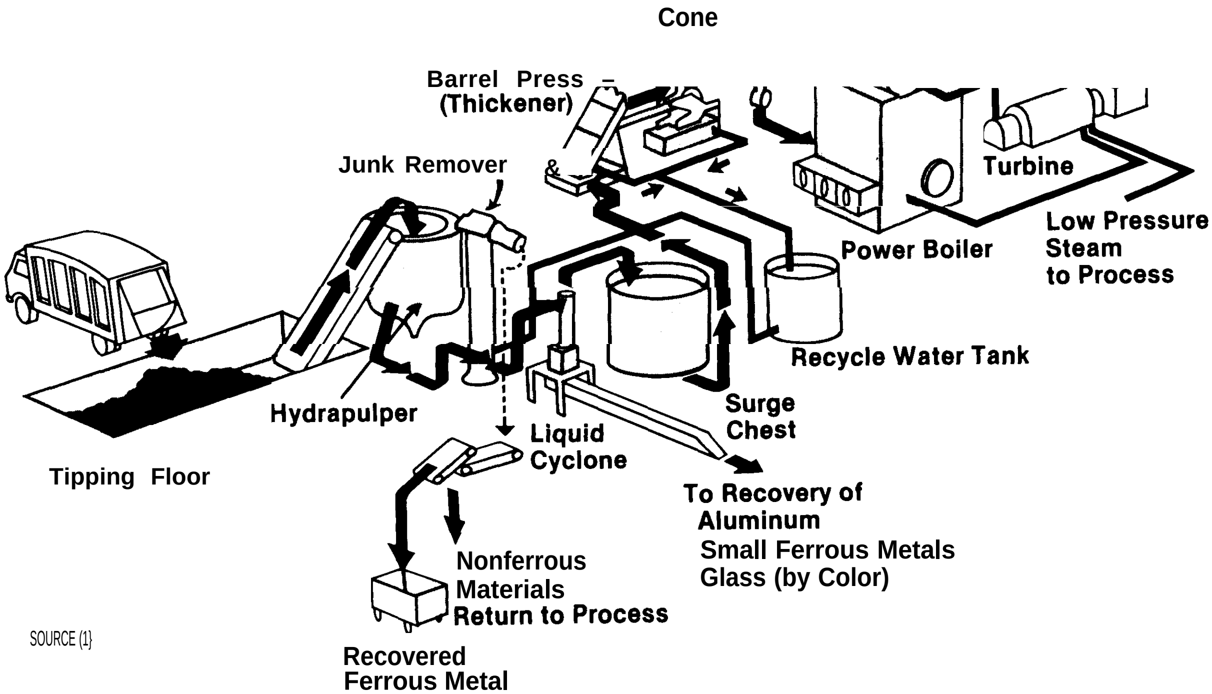
metals and other heavy organic and inorganic materials. The light material then goes through a rotating screen or "trommel" to remove abrasive fine sand, glass, and grit. The heavy materials from the air classifier and trommel move to a magnetic separating device that recovers ferrous material. Some plants also attempt to recover aluminum, glass, and mixed nonferrous metals, using processes described in a later section.

Based on experiences with the first generation of dry waste separation systems that employed shredding and air classification, attention has recently been given to a wider variety of processing schemes. One includes a trommel, or screening device, as the first processing step, to remove whole cans and bottles prior to waste shredding. In another variant, the shredder is eliminated and air classification is used as a first step. This is based, in part, on the concept that shredding, which is the locus of most operating explosions (see chapter 5), should be avoided. The best arrangement and design of first-stage dry mechanical separation processes is an important area of current research on resource recovery.

As shown in figure C-2, the light organic material from the trommel goes to a secondary shredder that further reduces the particle size to less than 11/z inches. The resultant material is called "fluff RDF. " Fluff RDF can be passed through a pelletizing or briquetting machine to yield "densified RDF. " The objective of densification is to improve storage, handling, and stoker-furnace burning characteristics. Alternatively, the light output from the trommel can be treated with a chemical embrittling agent and ground to a fine powder in a ball mill to produce a "dust or powdered RDF" with a particle size of around 0.15 mm. This is the basis of the Combustion Equipment Associates ECOFUEL-H[Q] process.

Figure C-3 illustrates the wet process RDF method. With this technology raw refuse is

Figure C-3.— Wet Process Energy Recovery System



SOURCE (1)

fed to a hydropulper (a machine like an oversized kitchen blender] where high-speed rotating cutters chop the waste in a water suspension. Large items are ejected and the remaining slurry is pumped into a liquid cyclone separator where smaller heavy materials are removed. Water is then removed to leave “wet RDF” with from 20- to 50-percent water content, which can be burned alone or as a supplement to coal, depending on its water content.

The wet pulping method has several advantages and disadvantages relative to the dry process. Sewage sludge can be mixed with the wet pulp prior to dewatering and the resulting mixture can be burned as a method of codisposal. Dewatering, however, is expensive and energy intensive. The wet process reduces the likelihood of explosion or fire in the size reduction phase, as compared to dry mechanical processing. It is possible to recover some organic fiber by the wet process. However, the quality of this fiber is insufficient for it to be used to produce paper. The only domestic application in one small plant at Franklin, Ohio, has been as a reinforcement in roofing material.

Pyrolysis Systems

Pyrolysis is destructive distillation or decomposition of organic materials in MSW at elevated temperatures in an oxygen deficient atmosphere. The product of pyrolysis is a complex mixture of combustible gases, liquids, and solid residues usable as fuels or chemical raw materials. The characteristics of the pyrolysis products depend on such variables as time in the reactor, process temperature and pressure, oxygen content of the gas in the reactor, particle size of the MSW feed, and the choices of catalysts and auxiliary fuels. Differences in these parameters distinguish the several proprietary processes that have been developed, Four proprietary systems are presently in some stage of demonstration. Two of these produce low-Btu gas: Monsanto’s Landgard and the Andco Torrax processes. The Union Carbide Purox system produces medium-Btu* gas. The Occidental Research Flash Pyrolysis process produces a liquid fuel.**

In the Monsanto system, figure C-4, MSW is shredded before it is pyrolized with a supplementary fuel in a large (20 ft diameter, 100 ft long) horizontal, refractory-lined kiln. Solid residue from the kiln is water quenched and separated into ferrous metal, glassy aggregate, and char. The char is dewatered and landfilled. In the Andco process, figure C-5, raw MSW enters a vertical shaft furnace after large items are removed and is pyrolyzed with auxiliary fuel. As the charge descends it is dried and converted to gases, char, and ash. The low-Btu gas produced must be burned onsite to produce steam or hot water.

The only Monsanto system in operation, a 1,000-tpd plant in the city of Baltimore, is currently undergoing modification to solve air pollution and other technical problems. Monsanto has withdrawn from the project. Andco has no plants in the United States. A 200-tpd plant is in startup in Luxembourg, and two others are under construction, one in France and one in West Germany.

In the Union Carbide Purox system, figure C-6, ferrous material is magnetically sepa-

*Low-Btu gas has a heating value of around 100 to 150 Btu per standard cubic foot (scf), the heating value of medium Btu gas is 300 to 400 Btu per scf. By comparison, natural gas has a heating value of about 1,000 Btu per scf.

**Liquid pyrolysis oil has a heating value of about 10,000 Btu per pound, roughly half that of No. 6 fuel oil.

Figure C-4.—The Monsanto Landgard System Produces a Low-Btu Gas Which is Immediately Burned Onsite for the Production of Steam

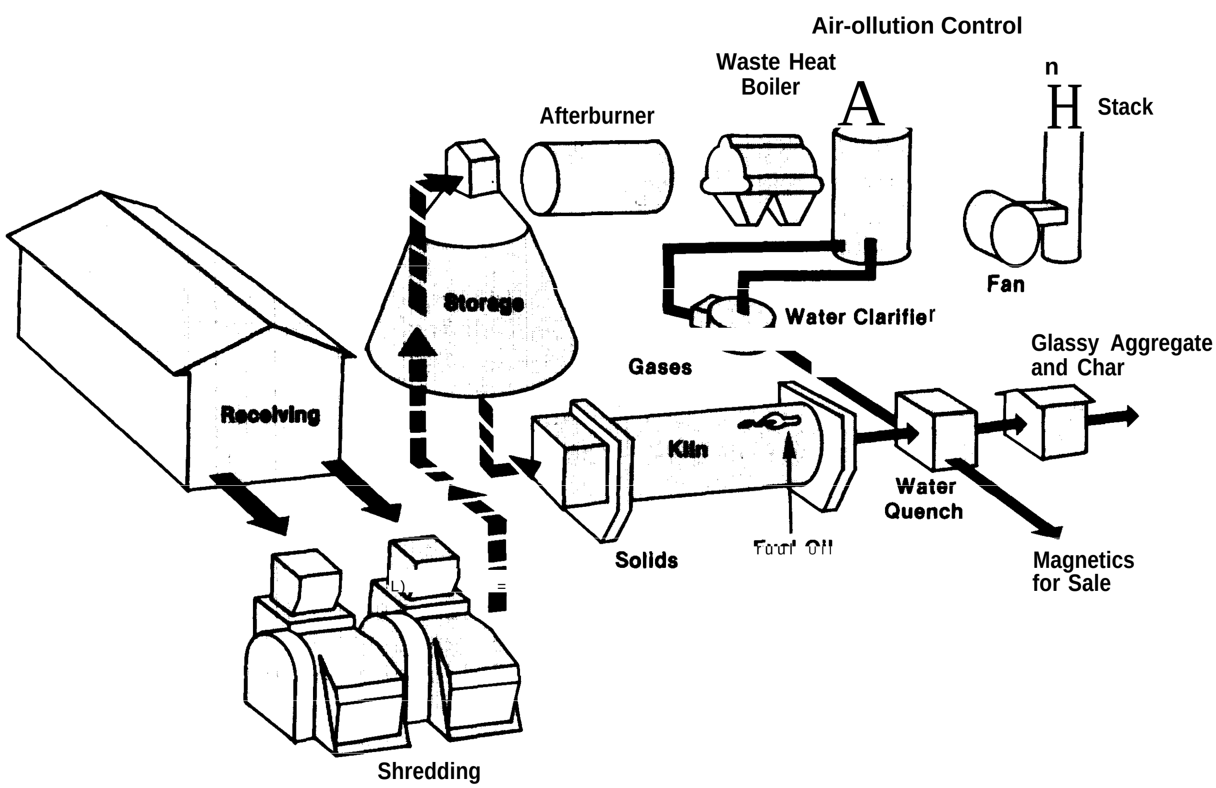
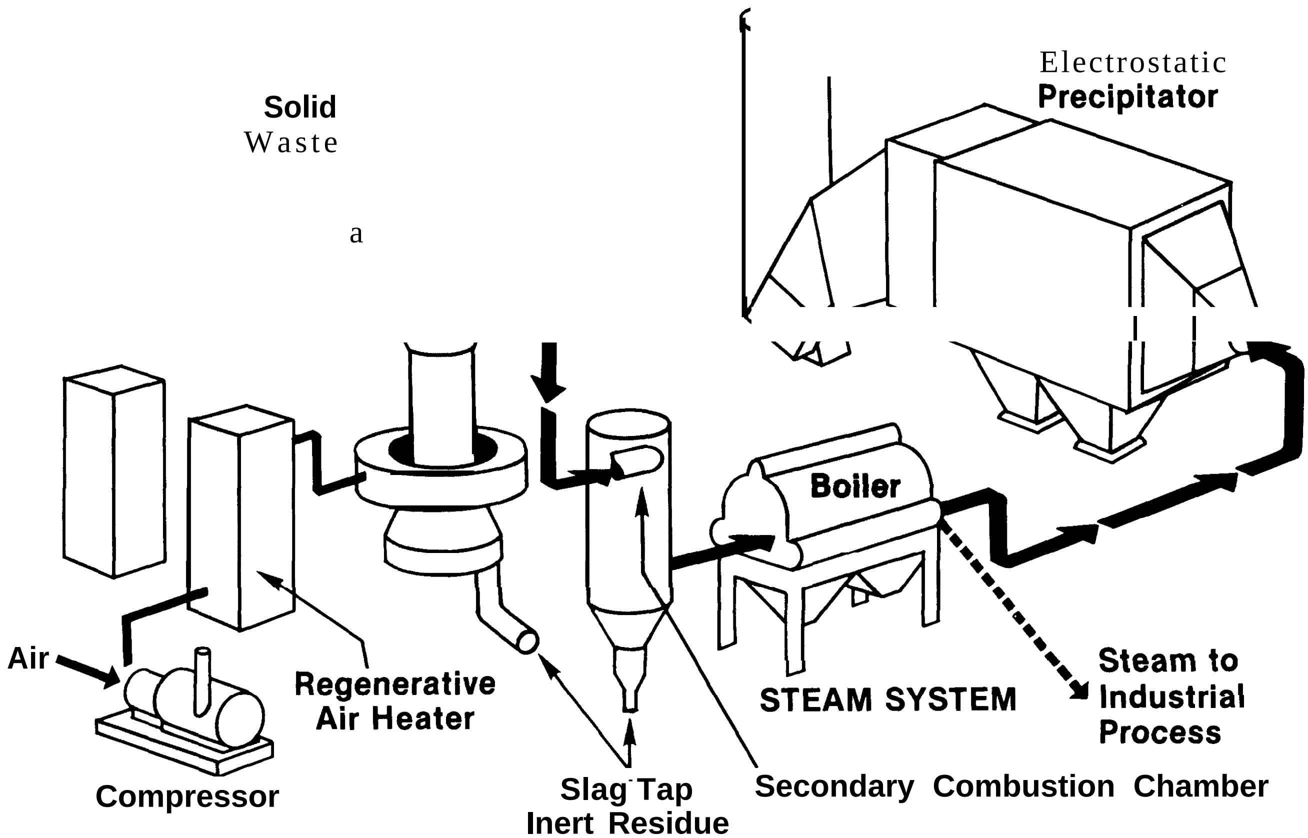


Figure C*5.—Torrax Slagging Pyrolysis System



ratecl from shredded MSW prior to feeding. Shredded refuse fed into the top of the vertical shaft furnace descends by gravity into zones of increasing temperature where drying. then pyrolysis, and finally char combustion and slagging take place. The temperature in the bottom zone, the slagging zone, is high enough to reduce the residual to a molten slag that continuously drains into a water quench to produce a hard granular aggregate material called frit, The Purox process feeds the furnace pure oxygen, rather than air as in the Monsanto and Torrax systems, and produces medium-Btu gas product. Its smaller volume and higher Btu content facilitates economic shipment over reasonably long distances. Union Carbide has been operating a 200-tpd demonstration plant at Charleston, W. Va., but no commercial facility yet exists.

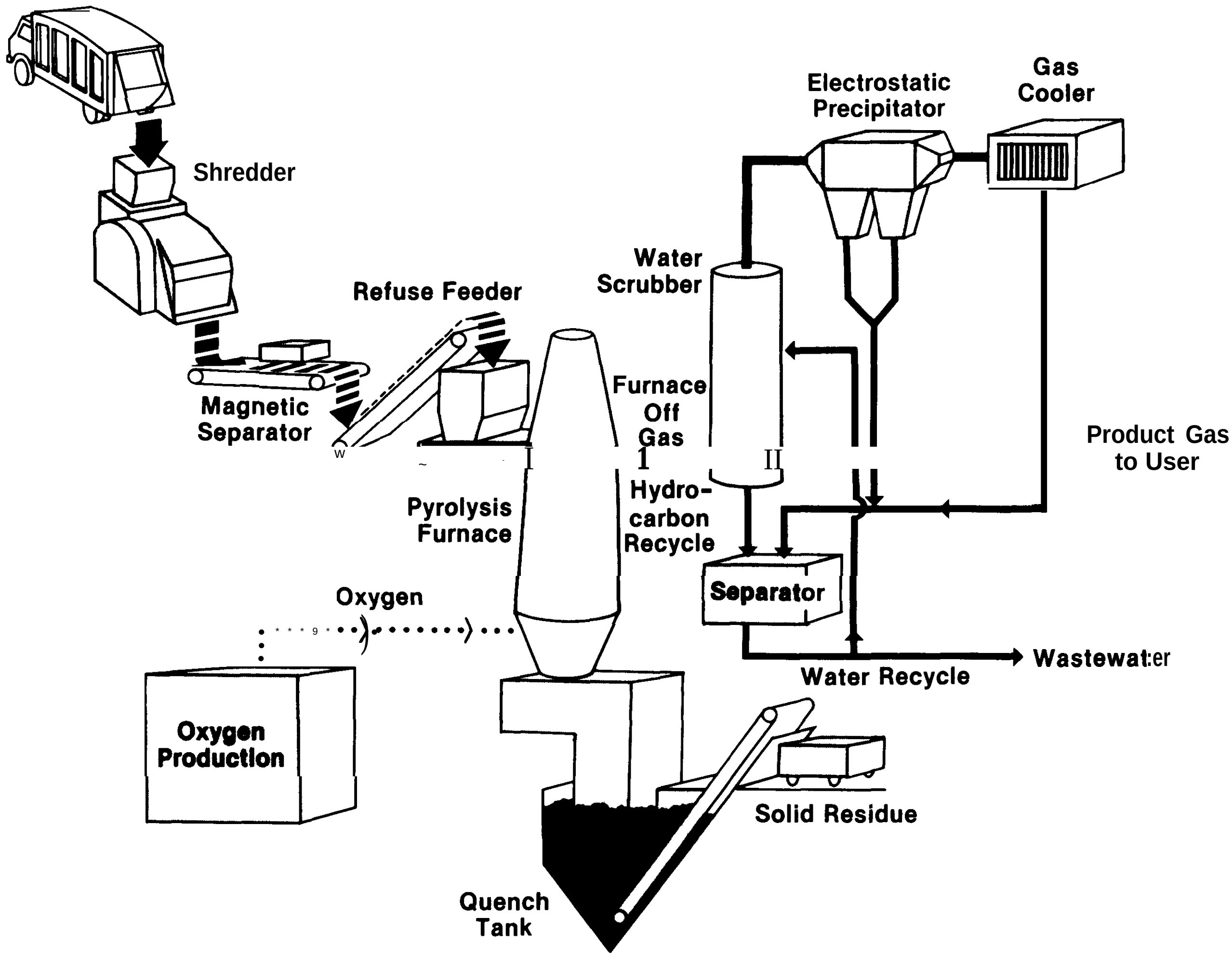
In the Occidental liquid fuel pyrolysis process, shown in figure C-7, raw MSW is first shredded and air classified to recover ferrous metal, aluminum, and glass prior to pyrolysis. The light organic fraction is dried, shredded again in an inert gas atmosphere, and then introduced to the pyrolysis reactor. Pyrolysis in the reactor vessel produces an oil-like fluid somewhat comparable to No. 6 fuel oil* that can be burned in existing oil-fired, steam-electric powerplants. A 200-tpd demonstration plant in San Diego County, Calif., was reported to be undergoing operational testing in early 1978. A subsequent report in May 1978 indicated that this system was not operating and faced major cost increases if it were to be continued.(5)

Biological Systems

This description focuses on three biological waste-to-energy technologies: recovery of

*Ibid,

Figure C-6.—Union Carbide Purox System Produces a Medium-Btu Gas for Sale to Offsite Users



methane from landfills, anaerobic digestion, and hydrolysis.

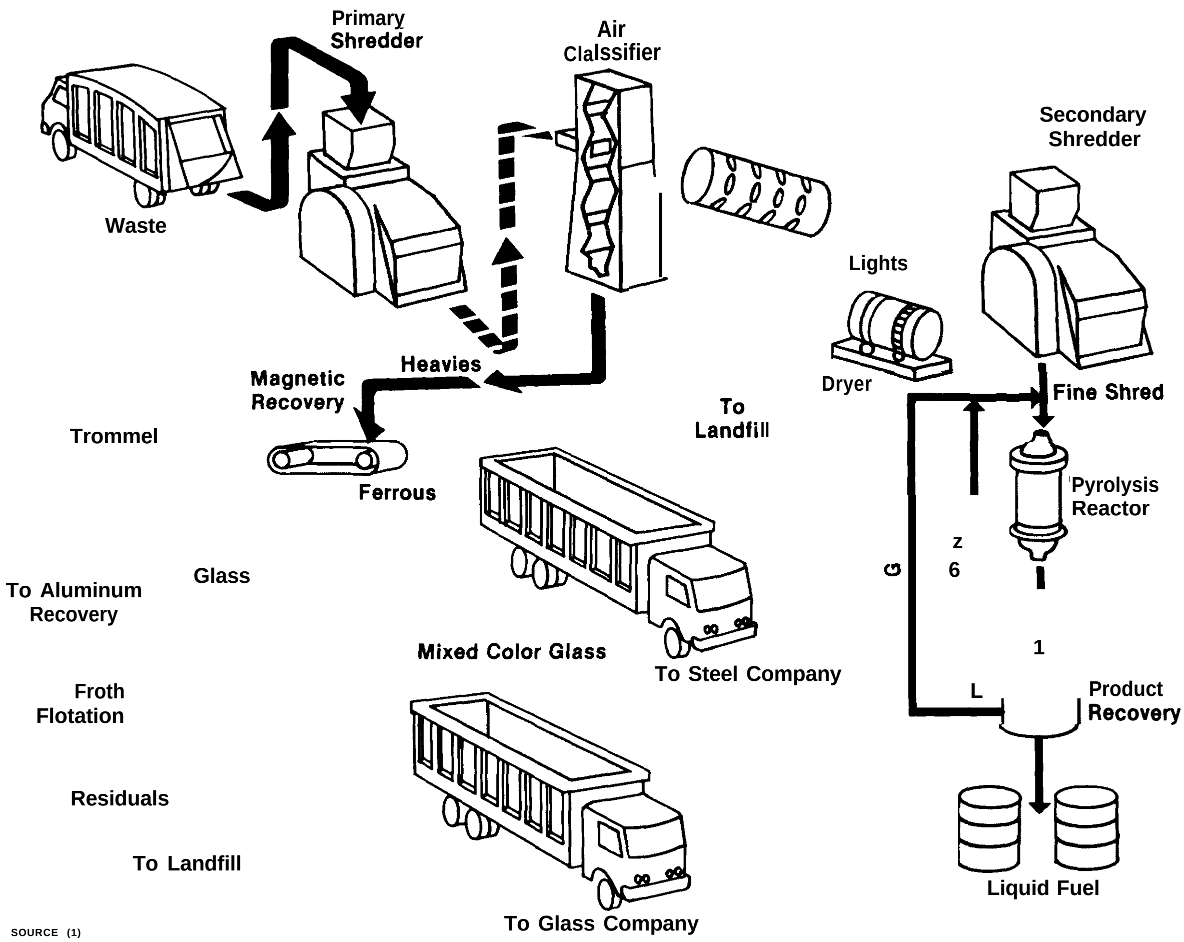
METHANE PRODUCTION FROM LANDFILLS

Natural decomposition of MSW in landfills produces a gas composed of roughly 50-percent methane and 50-percent carbon dioxide. If landfill geological characteristics are satisfactory, gas can be withdrawn through wells drilled into the landfill and can be treated to remove moisture, hydrogen sulfide, and other contaminants. Carbon dioxide can be removed leaving pipeline quality methane. Corrosion problems with this technology appear to be under control.(s) Recovery of methane from an old sanitary landfill is being explored at the Pales Verdes landfill at Los Angeles where approximately 500,000 cubic feet of purified methane is being recovered per day. Enough methane is recovered daily at the Pales Verdes site to meet the energy needs of some 2,500 homes.(5) EPA is evaluating several landfill gas-producing projects.(3)

ANAEROBIC DIGESTION

Methane can be recovered from anaerobic digestion of MSW in large tanks or reactors as shown in figure C-8. Anaerobic digestion of waste is accomplished by two types of bacteria: (i) acid formers that convert waste to organic acids, and (ii) methane producers that convert the acids to carbon dioxide, methane, and small quantities of other gases. One of the potential problems with methane

Figure C“7.—Production of Liquid Fuel From Solid Waste Using the Occidental Process

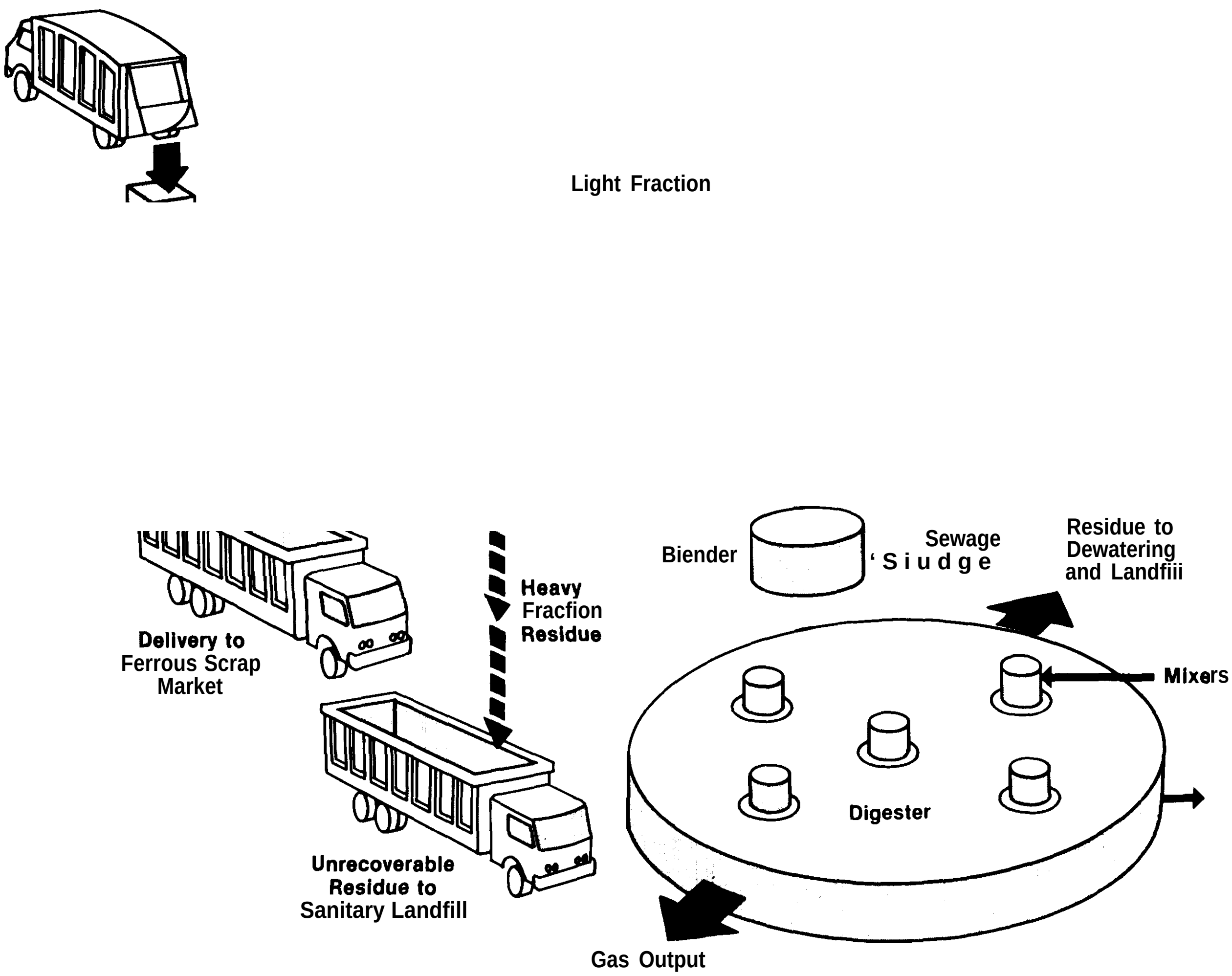


SOURCE (1)

generation is that MSW sometimes contains toxic components that can kill the methane-producing bacteria, Successful methane production from sewage sludge and animal manure can in part be attributed to the homogeneity of these substances and to the absence of bacteria-killing toxic contaminants.

A demonstration project to assess the feasibility of a 100-tpd anaerobic digestion system for MSW is being supported by the Department of Energy (DOE) at Pompano Beach, Fla., with startup expected in late-1978. At the Pompano Beach facility, MSW will be preprocessed to produce fluff RDF and recover ferrous metal, The wet RDF process could also be used. The RDF will be mixed with raw sewage sludge and introduced into digester tanks where it is mixed. The MSW-sludge mix will stay in the reactor around 10 days to capture the largest portion of the methane; longer retention times will produce more gas but at a rapidly decreasing rate. The gas produced by this process will contain approximately 50-percent methane and 50-percent carbon dioxide with a heating value of 540 to 700 Btu per cubic foot. The gas can be burned as is, without purification, or with further processing the carbon dioxide and traces of hydrogen sulfide can be removed to yield methane with a heating value of about 1,000 Btu per cubic foot. The digestion process produces large quantities of a liquid effluent, the majority of which will be recycled to the mix-

Figure C-8.—Biological Gasification of Solid Waste in Reactors



ing tanks, with the remainder discharged to a city sanitary sewer system, The remaining solids, about 17 percent of the refuse feed, must be either landfilled or burned in special-1y designed boilers. Schulz (6) estimates that approximately 3,700 cubic feet of methane will be produced per ton of MSW.

HYDROLYSIS

There are two processes for the production of ethyl alcohol (ethanol) from the organic portion of MSW by hydrolysis: (i) acid hydrolysis, which is a welI-developed industrial technology for nonwaste applications, and (ii) enzyme hydrolysis, a recent process still in the research stage. To convert cellulosic material to ethanol, it must first be hydrolyzed to produce sugar which then ferments to yield dilute ethanol that can be recovered by distillation. The production of ethanol from MSW by hydrolysis is not currently in the commercial or demonstration stage to our knowledge. Wilson (7) reports that Black Clawson is currently researching this area.

Considerable pioneering research in enzyme hydrolysis has been carried out at the U.S. Army Natick Development Center in Massachusetts. Natick's work in this area arose out of attempts to prevent biological decay of textile materials. Since 1972, they have been authorized to conduct studies of enzyme hydrolysis processes for converting cellulose wastes of military bases into useful products. The fungus Trichoderrna viride has been identified as having considerable enzyme productivity, with a potential for commercially feasible conversion processes.(8)

In addition, the Gulf Chemical Company is presently exploring the feasibility of constructing a demonstration plant (50 tpd of biomass feedstock) for the production of ethanol from municipal, agricultural, and industrial waste by enzymatic hydrolysis.(g)

Materials Recovery Systems

Several of the energy recovery systems just described include ferrous metal, aluminum, or glass recovery technologies. Other materials that can be recovered are paper fiber, compost, and other nonferrous metals.

Aluminum

The process for aluminum recovery is based on an eddy current separation system commonly called an aluminum magnet. With this technology, nonferrous conducting metals mixed with other wastes are conveyed through a magnetic field in such a way that an eddy current is induced in the metals. This current causes the metallic conductors to be repelled from the region of the magnetic field and thus out of the conveyor path. Nonmetallic are unaffected and are carried on. The device is quite sensitive and can be tuned to repel various shapes, densities, or materials. For example, it can be tuned, or optimized, to recover aluminum cans, the largest part of the aluminum waste. Eddy current separation equipment is currently installed at the following locations: National Center for Resource Recovery (NCRR) experimental test facility in Washington, D. C.; Ames, Iowa; Baltimore County, Md.; Occidental pyrolysis plant in San Diego, Calif.; the Americology plant in Milwaukee, Wis.; and in New Orleans, La. As reported in chapter 5, as of April 1978, none of these facilities was in steady production with a sustained commercial run.

Electrostatic separation is another method for separating nonferrous metals from organic materials. Mixed wastes pass between charged plates and are given an electric charge. Conducting materials such as aluminum lose their charge on an electrically grounded drum and fall off. Nonconductors retain their electrical charge and adhere to the drum. None of these systems is in use in full-scale plants. To further assist in cleaning contaminants from metals, a device called an "air knife" is sometimes used.

Glass

Two systems are being experimented with for the recovery of waste glass from MSW. Research is preceding on froth flotation, a standard mineral processing technique, for the recovery of glass. In this process the "heavy" portion of the waste stream, rich in finely ground glass, is slurried in water along with chemicals that cause the glass to become attached to air bubbles on the surface of the water. The glass floats out of the mix with the bubbles and is then washed and dried. Froth flotation is being explored at the NCRR facility in Washington, D. C.; in New Orleans, La.; and at the Occidental pyrolysis plant in San Diego. It is being installed in both the Monroe County, N. Y., and the Bridgeport, Corm., plants.

Since glass recovered by froth flotation produces mixed colored cullet, which has a limited market, the process of "optical sorting" is being examined. Glass particles around one-fourth inch in size are sorted, on the basis of their light transmission properties, into three colors, clear (flint), green, and amber. This process currently faces problems with high costs and its inability to reject a sufficiently large fraction of contained ceramics and stones to meet the quality standards required by glass producers. It also cannot recover particles smaller than one-fourth inch in size. Color sorting is being installed at the Hempstead plant in New York and has been used on a pilot plant basis at the Franklin, Ohio, facility.

Ferrous Metals

Ferrous metals have been removed from MSW by magnetic separators for a number of years. A recent study by the American Iron and Steel Institute identified nearly 40 such commercial installations in the United States. (I()) Some experience has been gained more recently in magnetic recovery of incinerated ferrous metals from the residue or ash from MSW incinerators. Such a device is currently in regular operation at the Saugus incinerator, but the recovered ferrous material is not currently being marketed. The U.S. Bureau of Mines has experimented with a complex mineral-technology-based process for "back-end" recovery of a variety of materials from incinerator residue.(11) Incinerated ferrous may be less marketable than the unincinerated product.

Compost

Comporting permits organic matter to decay to humus, which can be used for fertilizer or soil conditioner. Generally, comporting has not been economically successful because of difficulty in selling the humus product. According to EPA, only one comporting plant was operating as a commercial facility in 1976, the 50-tpd plant at Altoona, Pa.(3) A 1969 survey identified 18 plants with a total capacity of 2,250 tpd, indicating a major decline in U.S. comporting operations in this 7-year period.(12)

Comporting is successful in some European countries. In the Netherlands where markets for humus in the flower and bulb industries are good, the Government runs comporting operations. A technique for briquetting and joint comporting of MSW and sewage sludge has been developed in Germany. Its developers claim that the dried briquets can be used in food for pigs, as a soil conditioner, as a stable element in landfills, or as fuel.(2)

Fiber

Not many centralized resource recovery facilities can reclaim fiber from MSW for recycling as fiber. A 150-tpd demonstration fiber recovery facility has been operating since 1971 at Franklin, Ohio, using the Black Clawson wet process described earlier. Fiber recovered with this process is of poor quality, and it is sold to a nearby manufacturer of asphalt-impregnated roofing shingles. Two wet process plants, the Hempstead, .N.Y., facility now under construction, and the plant in Dade County, Fla., about to begin construction, will recover the fiber for use as a fuel, not for paper production.

A dry process for recovering paper fiber and light plastics has been developed by the Cecchini Company in Rome, Italy. Paper from this process is used with straw to make a low-grade paperboard. In general, the quality of the recovered paper is low and it has limited marketability. Roughly 23 percent of the paper in the input waste stream is recovered.(l) Other dry paper recovery processes, such as the Flakt process, which are being explored on a pilot plant basis in Western Europe, are described by Alter.(13)

Finally, some of the most recent plants (Milwaukee and New Orleans) feature limited paper recovery by hand-packing of bundled paper from the resource recovery plant input conveyor. This method has both economic and quality limitations.

Other Materials Recovery Technologies

There are many other materials recovery technologies which have not been addressed in this brief overview. The most important contemporary processes, however, have been touched upon. Readers wishing to explore further might do well to start with a review of the extensive research in this area carried out over the years by the U.S. Bureau of Mines.(11)

Additional Reading on Resource Recovery Technologies

1. Alter, H., and E. Horowitz, (editors) Resource Recovery and Utilization, (ASTM Special Technical Publication 592, proceedings of the National Materials Conservation Symposium, 29 April - 1 May 1974.
2. Environmental Protection Agency, The Resource Recovery Industry: A Survey of the Industry and its Capacity, report SW-50/c, 1976.
3. ______ Engineering and Economic Analysis of'Waste to Energy Systems, a report by the Ralph M. Parsons Company, June 1977.
4. ______, St. Louis Demonstration Final Report: Refuse Processing Plant—Assessment of Bacteria and Virus Emissions by Midwest Research Institute, Kansas City, Me., draft report August 1977. EPA Contract No. 68-02-1871, MRI Project No. 4033-L.
5. ______, St. Louis Demonstration Final Report: Refuse Processing Plant Equipment, Facilities, and Environmental Evaluations, by Midwest Research Institute, Kansas city, Mo,, September 1977. EPA-600 /2-77-155a.
6. ______ Evaluation of the Ames Solid Waste 'Recovery System, Part 1. Summary of Environmental Emissions: Equipment, Facilities, and Economic Evaluations, by Iowa State University and Midwest Research Institute, November 1977. EPA-600/2-77-205.
7. Levy, S. J., and H. G. Rigo, Resource Recovery Plant Implementation Guides for Municipal Officials, Technologies Report, U.S. EPA, SW-157.2, 1977.
8. Mantell, C. L., Solid Wastes: Origin, Collection, Processing, and Disposal, John Wiley, 1975.
9. Schulz, H., J. Benzier, B. Borte, M. Neomatalla, R. Szostax, and R. Westerhoff, Resource Recovery Technology for Urban Decision Makers, prepared for the National Science Foundation by the Urban Technology Center, School of Engineering and Applied Science, Columbia University, H. W. Schulz, et al., January 1976.
10. Pavoni, J,, J. Heer, and D, Hagerty, Handbook of Solid Waste Disposal, Van Nostrand, 1977.
11. Resource Recovery From Municipal Solid Waste, A State of the Art Study, National Center for Resource Recovery, Inc., Lexington Books, 1974.
12. U.S. Department of the Interior, Bureau of Mines Research on Resource Recovery Reclamation, Utilization, Disposal and Stabilization, Bureau of Mines Information Circular (IC 8750), 1977.
13. Weinstein, N. S., and R, F. Toro, Thermal Processing of Municipal Solid Waste for Resource and Energy Recovery, Ann Arbor Science Publishers, Inc., 1976.

References

1. Environmental Protection Agency, Resource Recovery *Plant* Implementation: Guides *for* Municipal *Officials,* Technologies Report, No. SW-157.2. Second printing 1977.
2. Department of Energy, European *Waste*-to-Energy Systems, An Overview. Report No. CONS-2103-6 prepared by Resource Planning Associates, Inc., June 1977.
3. Environmental Protection Agency, Office of Solid Waste Management, Fourth Report to the Congress, Resource Recovery and Waste Reduction, Publication SW-600, Aug. 1, 1977.
4. Hofmann, Ross, Associates, Evaluation *of Small* Modular Incinerators in Municipal Plants, Report SW-113c, done for EPA by Ross Hofmann Associates, Coral Gables, Fla., 1976.
5. Schwegler, Ron, Division Engineer, County Sanitation District of Los Angeles County, Calif., telephone communication, May 1978.
6. Schulz, H., J. Benziger, B. Bortz, M. Neomatalla, R. Szostak, G. Tong, G., and R. Westerhoff, Resource Recovery Technology *for* Urban Decision Makers, a report produced by the Urban Technology Center, Columbia University, for NSF, January 1976.
7. Wilson, E. M., J. Leavens, N. Snyder, J. Brehany, and R. Whitman, Engineering and Economic Analysis *of* Waste to Energy Systems, a report prepared by Ralph M. Parsons Co. for the EPA Industrial Environmental Research Laboratory, Cincinnati, Ohio, June 1977. (Available as EPA- 600/7-78-086, May 1978.)
8. Gaden, E. L., M. H. Mandels, E. T. Reese, L. A. Spano, (editors) Enzymatic Conversion *of Cellulosic* Materials: Technology and Applications, Symposium Proceedings held at Newton and Natick, Mass., Sept. 8-10, 1975. John Wiley and Sons, . 1976.
9. *Solid* Waste Report, July 31, 1978, p. 125.
10. American Iron and Steel Institute, "Summary Report of Solid Waste Processing Facilities" AISI, Washington, D. C., 1977.
11. U.S. Bureau of Mines, Bureau *of* Mines Research on Resource Recovery Reclamation, Utilization, Disposal, and Stabilization, U.S. Dept. of the Interior, Bureau of Mines Information Circular 8750, 1977.
12. Pavoni, J., J. Heer, and D. Hagerty, Handbook *of Solid* Waste Disposal, Van Nostrand, 1977.
13. Alter, H., "European Materials Recovery Systems, " Environmental Science and Technology, vol. 11, no. 5, May 1977.

Additional Information on Beverage Container Legislation

State Beverage Container Laws and Ordinances

Seven States have enacted mandatory beverage container deposit legislation: Connecticut, Delaware, Iowa, Maine, Michigan, Oregon, and Vermont. * Oregon and Vermont's legislation took effect on October 1, 1971, and September 1, 1973, respectively. (Vermont added several amendments to its original legislation which took effect July 1, 1975.) Laws in Maine and Michigan took effect in 1978, while Iowa and Connecticut will follow in 1979 and 1980. Delaware's law will become effective on July 11, 1979, or 60 days after Maryland and Pennsylvania pass similar legislation, whichever is later. South Dakota has passed a beverage container packaging law specifying that all beverage containers sold in the State subsequent to July 1, 1978, must be reusable, recyclable, or biodegradable. Virginia passed a law in 1978 that prohibited further adoption of deposit laws by local governments in the State.

While the objectives of each of these laws, except Virginia's are similar—to create incentives for manufacturers, distributors, retailers, and consumers of beverage containers to reuse or recycle them, the particular provisions of each law differ substantially. Table D-1 shows the major provisions of each law and illustrates the differences among them. Refund values vary from 2 cents for certified containers up to 10 cents for uncertified bottles; some States require special labeling; and all these States, ban flip tops.** Connecticut's law includes a provision to provide compensation for up to 2 years for an employee dislocated as a result of any provision of the Act.

'Referenda that would have placed mandatory deposits on beverage containers were defeated in the 1976 elections in Colorado and Massachusetts and in 1978 in Nebraska and Alaska.

**Flip tops or pull-tabs are also banned in California, Hawaii, Massachusetts, Minnesota, South Carolina, and Virginia.

A Comparison and Analysis of Beverage Container Legislation Studies by Research Triangle Institute and The Wharton School

In the last several years a number of analytical studies have appeared on the impacts and effectiveness of beverage container legislation, such as mandatory deposits or bans on nonreturnable containers. This appendix is a comparison of two major studies:

1. Energy and Economic Impacts of Mandatory Deposits prepared for the Federal Energy Administration (FEA) by Research Triangle Institute (RTI) and Franklin Associates Limited (FAL), September 1976.(1).
2. A Study of the Impacts on the U.S.A. of a Ban on One-Way Beverage Containers prepared for the U.S. Brewers Association (USBA) by the Wharton School and the Department of Civil Engineering of the University of Pennsylvania, December 1976.(2).

The purpose of this appendix is to compare the scope, assumptions, methods, and findings of these two studies in order to identify

Table D-1 .—Characteristics of State Beverage Container Deposit Laws

	States which have enacted mandatory beverage container deposit laws						
Characteristics	Connecticut	Delaware	Iowa	/aine	Michigan	Oregon	Vermont
Status of law	Enacted	Enacted	Enacted	Enacted referendum	Enacted Referendum	Enacted	Enacted 4/10/72 Amended 4/30/75
Effective date	1/1 /80	7/1 1/79 or 60 day: after Maryland and Pennsylvania enact similar legislation which ever IS later	/1 '79 for all but liquor provisions /1/79 for liquor provision	/1/78	11/1/78	1 0/1/71	Original Act 9/1/73 Amended 7/1/75
Refund amount	5 or more	5 or more	5 or more	5 or more	5c or more' 10$ or more	2c or more' 5c or more	5 or more
Handling fee paid by distributer to dealer	1 or more	20°. of refund	Limit to 113 max - num handiling	1 or more			20%. of refund
Types of beverages covered	Beer Malt beverages Mineral water Soda water Carbonated soft drinks	Beer Malt beverages Ale Mineral water Carbonated soft drinks	Beer Malt beverages Mineral water Soda water Carbonated soft drinks	leer Ale Soda water Carbonated so drinks	Beer, ale Soda water Mineral water Carbonated soft drinks Malt beverages	Beer Malt beverages Mineral water Soda water Carbonated soft drinks	Beer Malt beverages Mineral water Carbonated soft drinks
Refund value must be clearly marked on container?	Yes, embossed, stamped, or labeled	Yes on label or 01 top of container. l/4.inch type re fillable bottles exempt	es except for those which are already labeled otherwise	es	Yes, embossed, stamped, or on label	Yes, embossed, stamped, or on label	Yes, on label Refillable bottles exempt
State name must be clearly marked on container?	Yes, 1\2 inch type Embossed, stamped or labeled	Nonrefillable glass containers	10, but expect Department which IS administering Act to eventually print on container	10	Yes, embossed, stamped, or on label	No	Yes, on label in 1/2 inch type, re fillable bottles exempt
Type of containers banned if any?	—	Yes if not biode. gradable or photo degradable			—	—	Non biodegradable Glass nonreturn- able containers
Flip tops banned?	Yes		es	es	Yes	Yes	Yes
Plastic 6-pack rings banned?	No		o	es	No	No	Yes
Who must accept returned con- tainers	Dealer, Distributor	Dealer Distributor	Dealer, Distributor	Dealer, Distnbutor	Dealer, Distributor	Dealer, Distributor	Dealer, Distributor
Allowable reasons for refusal to accept returned containers?	Labeling not correct, if redemption center in area, dam aged/dirty	If redemption cen ter in area, bottle damaged, or un- clean, more than 120 being re. turned within a 1. week period	bottle amaged	redemption center in area	If refund value and State name are not on bottle	Refund value not stated; redemp- tion center in area	Labeling incorrect Size/brand; jamaged/dirty
Are redemption centers per. mitted?	Yes	Yes	Yes	es	Yes	Yes	(es
Penalty for noncompliance	—	21 VII penalty $250 to $1,000 and/or an injunction or restraining order	Misdemeanor	Civil penalty 100	Fine not less than $100 nor more than $1 ,00(	Both civil and criminal penalties: dependlng on in. fraction	Fine $1,000 per violation

'Lower deposit provided for certified standard bottles that can be used by a number of firms areas of agreement and disagreement and to show the origins of any disagreement between them.

Background of Analyses of Beverage Container Legislation

The proponents of container legislation usually suggest one or more of the following goals as the motivation their proposals:

1. reduced litter
2. reduced solid waste
3. energy conservation
4. materials conservation
5. strengthening of the conservation ethic

These goals are the primary objects of analyses of the effectiveness of various proposals.

In addition to the intended goals, it is realized that container legislation would have a number of other impacts. While quite a few such impacts have been discussed, the following have been given the most attention:

1. employment
2. capital investment
3. profits
4. beverage sales
5. consumer costs
6. air and water pollution

No one currently knows how to predict the complete response of the economy to container legislation from first principles, or with any certainty. Therefore, most studies are "partially parametric, " in the sense that one or more of the following factors are treated as parameters whose values partially determine the system response:

1. trippage or return rate for each beverage and container type
2. market shares for each container type and material
3. litter rate
4. recycling rate for disposed containers

At the current state of the art, predicting the values of these parameters is largely judgmental. Once the values of the parameters are chosen and assumptions made about future technology, it becomes largely an engineering accounting task based on material and energy balances to estimate the effectiveness of container legislation in reaching its primary goals, as well as its impact on air and water pollution. In addition, economic models of different degrees of sophistication are used to supplement the parametric analysis in order to estimate the impacts on employment, investment, profits, costs and prices, and sales.

Family Tree of Existing Analyses

Three main streams of analytical work on beverage container legislation can be identified:

1. A series of reports done for the Environmental Protection Agency (EPA) and FEA by RTI, Midwest Research Institute (MRI), and FAL, culminating in the September 1976 report by RTI.(1) (The principals of FAL were part of the MRI staff in this area. Further, a significant part of the report by RTI was subcontracted to FAL, particularly the energy impact study.)
2. Studies done for the USBA by R. S. Weinberg and Associates and by the Wharton School culminating in the December 1976 report by the Wharton School. The Wharton School has done work for Busch Breweries in the past, and Weinberg was the project officer for USBA on the Wharton study. Weinberg has done a series of reports and analyses of other reports for USBA.(3)
3. Several additional studies that have drawn heavily on the analyses of the RTI/MRI/FAL series. These include:

   a. the OECD report (4)
   b. the GAO report (5)
   c. the Michigan report (6)
   d. the EPA 4th Report to Congress chapter on deposit legislation (7)
   e. the staff report of the Resource Conservation Committee (RCC).(8)

These studies often contribute additional insight or manipulate the data for specific needs, but all are heavily dependent on the RTI/MRI/FAL series.

In addition to these three groups, there exist some early studies in the field, especially Hannon's,(9) as well as several studies which have examined the Oregon and Vermont experiences.(10, 11,12) The latter are often used in making estimates of parameter values to be used in nationwide models.

Scope, Assumptions, and Methods of the Research Triangle Institute and Wharton School Studies

The RTI study tries to answer the question, "What might happen if a mandatory beverage container deposit system were initiated in the late 1970's?"

The Wharton School study tries to answer the question, "What might have happened if nonreturnable containers had been banned and if a deposit system on the remaining refillable containers had been initiated during the period 1969 through 1974?"

Table D-2 compares the detailed scope, assumptions, and methods of the two studies. The Wharton School did a retrospective analysis of a hypothetical ban on nonreturnable containers. This approach reduced the number of assumptions to be made about costs, technology, sales, market shares, and return rates because the base case of no legislation could be taken to be the actual historical record. Their assumption of a ban on nonreturnables simplified th~analysis since it included disappearance of all cans and nonreturnable bottles and required complete conversion of the industries involved to refillable glass. The Wharton economic analysis is based on a ''cost-plus'' model of pricing in each industrial sector in which it is assumed that each industry maintains the same return on investment after the ban takes effect as before. Considerable effort was expended on estimating investment requirements. Finally, they use a sophisticated model of the complete U.S. economy to estimate secondary impacts of the ban.

The RTI and FAL performed a prospective analysis of a hypothetical deposit system mandated by Federal law in 1978. Forecasts are made of future beverage sales and future container technologies; the latter in terms of unit energy requirements and weights. The methodology allows for investigation of a full range of container market shares and return rates, but to simplify presentation of the results, two scenarios are selected to illustrate possible system behavior. The authors emphasize that the scenarios are neither most probable nor extremes and that users must evaluate their own scenarios to use the results effectively. Differences in capital stock for the no-deposit and with-deposit situations are evaluated based on the plant and equipment requirements to meet demand under the two conditions. The pricing model used assumes that cost changes are reflected directly in shelf price changes without mark-up. Increased handling costs tend to raise prices, while the scrap value of returned containers and the retained deposits tend to reduce prices. Analysis of secondary impacts was limited to changes in employment, employee earnings, and output of primary materials industries.

Neither study evaluated the impact of the laws on materials consumption, solid waste, air and water pollution, or the conservation ethic. Wharton presented a brief estimate of impacts on costs of litter control. Both presented final results in terms of plausible scenarios as follows:

Wharton School Standard Scenario
- no cans or nonreturnable bottles
  - trippage = 8
- no change in beverage demand

RTI Scenario I
- no nonreturnable bottles
- can sales equal to those for 1976
- trippage = 10 for bottles (return rate 0.9)
- recycle rate for cans = 0.9
- small reduction in beverage demand

Table D-2.—Scope, Assumptions, and Methods of the Research Triangle Institute and The Wharton School Studies

Characteristic	Wharton School	Research Triangle Institute
Nature of study.	Nonreturnable ban with supplementary deposit system	Mandatory deposits
Deposit level	Beer, 5cent soft drinks 6cent	5cent
Date legislation begins	1969	1978
Date legislation fully effective	1974	1982
Cans banned?	Yes	No
Nonreturnable bottles?	Banned	Disappear
Bottle return rates in final scenario(s)	0.875 (8 trips)	0.8 and 0.9 (5 and 10 trips)
Can return rate	Irrelevant	Same as bottle return rate
Technological change	None	All containers improve by 1982
What happens to returned cans?	Irrelevant	All recyled
Steel/aluminum market share for cans	Irrelevant	Same as projected without deposits
Refillable beer bottle type. . . .	12 oz. export or 12 oz. stubby	11 oz. stubby
Pricing model	"Cost-plus," dynamic	"Competitive," static
What happens to unclaimed deposits?	Partially retained as income by brewers and bottlers	Reflected in lower consumer prices and in offsets of additional costs
Industry profits.	Return on investment assumed same for each sector with and without legislation	Not evaluated
Method of estimating higher order impacts on the economy	Complete simulation on Wharton model of the economy	Only done for primary material production

RTI Scenario II

- no nonreturnable bottles
- can sales equal to one-half of those for 1976
- trippage = 5 for bottles (return rate 0.8)
- recycle rate for cans = 0.8
- small reduction in beverage demand

Because these studies have such different scope, it is difficult to compare them. The major difference lies in the assumption by the Wharton School that nonreturnables are banned by legislation. This assumption creates large impacts on investment and allows Wharton to draw a number of qualitative conclusions about barriers to future technological development, loss of intercontainer competition, increased consumer inconvenience, and restricted freedom of choice which tend toward a very rigid, noncompetitive system. These findings arise, however, as a result of the ban, not as a result of a deposit requirement.

Comparison of Findings of the Research Triangle Institute and The Wharton School

Table D-3 compares the findings of the two studies for their final scenarios with regard to energy, beverage sales, employment and earnings, and investment. Because the two studies present results for time periods 8 years apart, the findings are compared on a normalized per-ounce of sales basis in table D-4. This mode of presentation is intended to correct for large shifts in the overall sizes of the industries from 1974 to 1982, Wharton School only provided a "no-ban" base case

Table D.3.—Findings of the Research Triangle Institute and The Wharton School Studies

Finding	Wharton a	RTI	
	Standard scenario 1974	Scenario I 1982	Scenario II 1982
Total annual energy saving for beverage delivery	147 to 226 X 10^{12} Btu	168 X 10^{12} Btu	144 X 10^{12} Btu
Percentage annual energy savings for beverage delivery.	36% to 56%	44?L0	38%
Impact on employment in “core industries”b (jobs).	+ 54,946 (export) + 48,154 (stubby) + 50,000 (nominal)	—	—
Impact on employment in all industries (jobs) . . .	+ 133,000 (net) + 176,000 (gained) – 38,000 (lost)	+ 18,000 (net) + 56,000 (gained) – 38,000 (lost)	17,000 (net) 66,000 (gained) 49,000 (lost)
Impact on investment in core industries (billion dollars)	+ 4.1 C to 4.5d	+ 1 .5e	+ 2.4e
Net impact on employee earnings (million dollarsiyear)	+ 559 to 648f	+ 879	+ 936
Annual beverage consumption (billion ounces) . .	1,139	1,890	1,890

aTwo subscenarlos were examined for cases In which brewers adopt export (traditional) or stubby returnable bottles
b core industries are brewers, wholesalers, bottlers, retailers, and can and bottle manufacturers ‘
c lncludes $1.0 billion for additional returnable Container inventory Or “float. ”
d Includes $1.1 billion for float.
‘Does not Include float
‘Core industries only

Table D-4.— Findings of the Research Triangle Institute and The Wharton School Studies Per Unit Beverage Consumption

Finding	Wharton	RTI	
	Standard scenario 1974	Scenario I 1982	Scenario II 1982
Energy savings in beverage delivery (Btu/ounce)	129 to 198	88	76
Net change in employment in all industries (jobslbillion ounces).	+ 104	+ 62	+ 62
Impact on investment in core industries ($/1,000 ouncelyear).	+ 3.6 to 4.0	+ 0.8	+ 1.3
Net impact on employee earnings ($/million ounces). . . . ., ...	+ 491 to 569	+ 465	+ 495

that would facilitate comparisons of the studies on a percent change basis for total system energy consumption.

The interesting thing about the findings reported in tables D-3 and D-4 is the agreement between the two studies on potential energy savings, on employment changes, and on net employee earnings increases. This agreement is most surprising in view of the different assumptions and study perspectives. Nevertheless, within the accuracy which can be hoped for from any such analysis, the two studies appear to agree, perhaps fortuitously, in the critical areas of energy, employment, and employee earnings.

The two studies disagree considerably on investment requirements. On a normalized basis, Wharton School projects greater additional investment expense by a factor of 3 to 6 (see table D-4.) the studies disagree for at least three reasons, the relative importance of which we have been unable to assess. First, the Wharton School assumption of a ban on nonreturnables necessitates a higher level of investment in bottle handling equipment. Second, Wharton School uses a 3-year phase-in period, while RTI’s is longer (4 years). This allows a more orderly replacement of capital by RTI. Third, USBA (Weinberg) argues that RTI overestimates the degree to which existing equipment can be converted and thus underestimates additional expense. In one sense, Wharton School should have underestimated capital needs, since in the 1969 base year the beverage system was less committed to nonreturnables than it was in the RTI base year of 1978. (See chapter 9 for further discussion of investment impacts of BCDL.)

Federal Experience With Beverage Container Deposits

On September 21, 1976, the EPA promulgated Federal guidelines dealing with beverage containers for carbonated beverages (soft drinks and beer) .(13) These guidelines require that a 5-cent deposit-refund system be established for all beer and soft drinks sold on Federal facilities, such as national parks and Federal agencies, unless such a system is determined to be infeasible for certain enumerated reasons. These guidelines, promulgated under authority in the Resource Recovery Act of 1970, which amended the Solid Waste Disposal Act of 1965, have a compliance deadline of September 21, 1977.

These guidelines have two primary goals: (1) a reduction in beverage container solid waste and litter; and (2) the conservation and more efficient use of energy and materials resources.

Approximately 20 Federal agencies have or are in the process of implementing a refillable beverage container deposit system in all or part of their properties (there are 27 Federal agencies to which these guidelines do not apply). See table D-5 for agencies implementing the guidelines.

Several Federal agencies have tested the implementation of such a deposit system. The results of two test programs—one by the Department of Defense on 10 military bases. and a second initiated by Yosemite Park and Curry Company with support of the National Park Service and the EPA at Yosemite National Park—are discussed here.

Table D"5.—Federal Agencies That Are Implementing or Have Implemented a Deposit Refund System

Civil Aeronautics Board
Commodity Futures Trading Commission
Department of Agriculture
Department of Commerce
Department of Defense
Department of Energy (some facilities will implement and some will not)
Department of Health, Education, and Welfare (in process of deciding which facilities will implement)
Department of Interior (in process of deciding which facilities will implement)
Department of Transportation (some facilities will implement and some will not)
Department of Treasury
Environmental Protection Agency (some facilities will implement and some will not)
Federal Deposit Insurance Corporation
Federal Reserve
General Services Administrate ion
International Trade Commission
National Aeronaut ics and Space Administrate ion
National Science Foundation (some facilities will implement and some will not)
Tennessee Valley Authority
Veterans Administration

SOURCE: (14)

Department of Defense Test

The Department of Defense (DOD), with the EPA's support, and a contractor, FAL, undertook a l-year DOD Beverage Container Test program at 10 military installations. (15) The objectives of this test program were:

- To field test the EPA's guidelines for mandatory beverage container use,
- To determine the effect in a test situation of beverage container deposits on beverage container use and return patterns,
- To test the EPA guidelines at selected DOD facilities,
- To determine the costs and benefits at DOD facilities of implementing the EPA guidelines including measurable economic impacts and beverage container use and return patterns under a 5-cent deposit system, and

- To develop decision criteria for DOD on the implementation or nonimplementation of the EPA guidelines at military facilities.

The recommendations of the task force that ran the test program were that EPA guidelines for beverage containers should not be implemented fully or selectively on U.S. military bases. * However, refillable containers should be available in military sales outlets where economically feasible when competitive off-base outlets are not similarly restricted: the test results indicated an average dollar sales loss of 25.4 percent at the military installations when competitive off-base sales outlets were not operating under a deposit system. However, the task force stated that DOD installations will continue to actively implement State deposit laws in those States having such laws.

The recommendations of this task force are under review by the Deputy Assistant Secretary of Defense for Energy, Environment, and Safety. The final decision on how DOD will respond to EPA's Beverage Container Guidelines will be made by the Secretary of Defense.

Yosemite National Park Test

The Yosemite Park and Curry Company, with the support of the National Park Service and EPA, tested a 5-cent deposit on all beer and soft drink containers sold in Yosemite National Park.(16) The system was implt+ mented in May 1976 for a 4-month test period. After the test, it was decided that the deposit system should be established on a permanent basis. The findings of the 4-month test period, May-August 1976, can be summarized as follows:

- Beverage sales and packaging mix. Two analyses were undertaken regarding the impacts of initiating a deposit system on beverage sales—one based on total sales and one on vending machine sales. Both analyses showed that the beverage sales were below the expected sales for 1976. However, a number of reasons, other than the initiation of a deposit system, may have affected the sale of beverages including the number of visitors to the park, weather, and beverage price increases.

  Throughout the summer consumers continued to buy beverages in the available containers in the same proportions as they did before the deposit system (7-up and Shasta were removed from the market because they were packaged in bimetal cans. The reason for this action was the absence of an adequate market for recycled bimetal cans). Ninety-eight percent of beverage sales are in cans.
- Return rates for containers. Seven out of ten beverage containers sold in Yosemite were returned in the summer of 1976.
- Recycling, solid waste, and litter. Cans marked for a deposit refund were rarely found as litter in the park. During the summer approximately 30 tons of beverage containers were recycled. Overall, there was a solid waste reduction of 30 tons.
- Economics. The economics of the deposit system test were estimated by comparing the revenues (scrap value of the returned containers and the forfeited deposits on containers which are not returned) with the costs (handling, labeling, equipment and supplies, labor, etc.). It was estimated that for the summer the system broke about even. However, it was also estimated that for future summers, the system could anticipate a profit of about $8,000.

*EPA representatives on the task force believed that it was both inappropriate and a conflict of interest to participate in a process directed toward the establishment of a policy on EPA's Beverage Container Guidelines, The EPA representative, therefore, did not participate in the development and final adoption of the task force's recommendations.

References

1. Bingham, Taylor H., et al., Energy and Economic Impacts *of* Mandatory Deposits, Research Triangle Institute, Research Triangle Park, N. C., for the Federal Energy Administration, September 1976. Available as NTIS PB-258-638.
2. Ackoff, Russell L., et al., A Study *of* the Impacts on the USA *of* a Ban on One-Way Beverage Containers, prepared for the U.S. Brewers Association by Busch Center, The Wharton School, University of Pennsylvania, December 1976.
3. U.S. Brewers Association, Inc., *Reference* Source Book: Research Materials Supporting The United States Brewers Association's Arguments Against Restrictive Packaging Legislation (contains eight analyses prepared for the USBA on the subject of mandatory deposit legislation. These analyses were published by the USBA between December 1971 and October 1976.), January 1978.
4. Organization for Economic Cooperation and Development, Environment Directorate, *Re-Use* and Recycling *of* Packaging Materials Beverage Containers Case Study, *Draft Final* Report, Env/WMP/ 77.2, Paris, France, January 1977.
5. General Accounting Office, Potential *Effects of* a National Mandatory Deposit on Beverage Containers, Report # PAD-78-19, Dec. 7, 1977.
6. Michigan Public Service Commission, Economic Analysis *of* Deposit Regulation on Non-Returnable Beverage Containers in Michigan, M. P.S.C. Staff Study 1975-3, State of Michigan, Department of Commerce, Lansing, Mich., October 1975.
7. U.S. Environmental Protection Agency, Resource Recovery and Waste Reduction, Fourth Report to Congress, EPA-SW-6OO, August 1977.
8. Resource Conservation Committee, Committee Findings and *Staff* Papers on National Beverage Container Deposits, Second Report of the Resource Conservation Committee, January 1978.
9. Hannon, Bruce, "System Energy and Recycling: A Study of the Beverage Industry," Report Number 23, Center for Advanced Computation, University of Illinois, Urbana-Champagn, Mar. 17,1973.
10. Waggoner, Don, "Oregon's Bottle Bill Two Years Later, " Oregon Environmental Council, 1974.
11. Jeffords, James M., and D. W. Webster, "Vermont 5¢ Deposit, November 1977. "
12. Nadworny, Milton J., Some Economic Consequences *of* the Vermont Beverage Container Deposit Law, University of Vermont, February 1975.
13. Federal Register, vol. 41, no. 184, Sept. 21, 1976; pt. II, pp. 41202-41205.
14. Thompson, Marian, EPA Solid Waste Program, telephone conversation, May 1979.
15. Department *of Defense* Test *of* the Environmental Protection Agency's Guidelines on Beverage Containers, Report prepared by DOD-EPA Joint Executive Agency Task Force and Franklin Associates, Ltd., March 1979.
16. *Final* Report: Yosemite National Park Deposit Experiment, prepared for EPA by Research Triangle Institute under contract 68-01-2981, April 1977.

ACRONYMS, ABBREVIATIONS, AND GLOSSARY

LIST OF ACRONYMS AND ABBREVIATIONS

API . . . . American Paper Institute
ARM . . . . action research model
ASTM ... , ... American Society for Testing and Materials
13CDL. . . . . beverage containerdeposit legislation
BIRP . . . . beverage industry recycling program
BOD . . . . biochemical oxygendemand
bpd . . . . barrelsperday
Btu . . . . British thermal units
LEA. ...,... CombustionEquipment Associates
COD . . . . chemical oxygen demand
DOC . . . . Department ofCommerce
DOE. . . . . Department ofEnergy
ECOFUEL-II®. trade nameforaprocessed fuel fromwaste
EPA. . . . . Environmental Protection Agency
ERDA . . . . EnergyResearchand Development Administration
FAD. ..,.... Franklin Associates, L’td.
FDA. . . . . FoodandDrug Administration
FEAR . . . . Federal Energy Administration
FTC. . . . . Federal Trade Commission
FE Y . . . . fiscal year
GAO . . . . General Accounting Office
GSA. . . . . General Services Administration
HUD . . . . Department ofHousingand Urban Development
Icc .. . . Interstate Commerce Commission
INOKY . . . . . . Indiana/Ohio/Kentucky region
IRS . . . . Internal Revenue Service
IRTC . . . . International Research and Technology Corporation
ISIS. . . . . Institute of ScrapIronand Steel
KAB . . . . Keep America Beautiful, Inc.
MU. . . . . modular combustion units
MIRE. . . . . . . The MITRECorporation
MRI. . . . . Midwest Research Institute
MAW. . . . . municipal solid waste
NARY. . . . . National Associationof Recycling Industries
NCRR . . . . National Center forResource Recovery
NIOSH . . . . . . National Instituteof Occupational Safety and Health
NSDA . . . . National SoftDrink Association
OECD . . . . Organisation for Economic Cooperation and Development
ORB . . . . Office ofManagementand Budget
OSHA . . . . Occupational Safety and Health Administration
OTA . . . . Office ofTechnology Assessment
PET . . . . polyyethylene terephthalate
RCC. . . . . Resource Conservation Committee
R&D. . . . . research and development
PDF. . . . . refuse-derived fuel
RCRA . . . . Resource Conservationand Recovery Actof1976(public Law94-580)
RPA. . . . . Resource Planning Associates
RR. . . . . return rate
RTC. . . . . Resource Technology Corporation
RTI . . . . Research Triangle Institute
tad. . . . . tonsperday
USBA . . . . United States Brewers Association
W%.. . . . . voluntary product standard

Aerosol—A suspension of fine solid or liquid particles in a gas.

Aggregate—A mixture of small solid particles (stones, glass, ceramics, metal) obtained in separation of MSW.

Air classifier—A device that uses a moving stream of air to separate light waste components (paper, plastic film, textiles, dust, leaves, foil, etc.) from heavy components (glass, metal, wood, bulk plastic, etc.).

Air knife-A device that uses a horizontal blast of air from a thin slit to separate light from heavy components of a falling solid waste stream.

Aluminum magnet—A device that uses eddy-current forces to separate aluminum and other light nonferrous metals from a solid waste stream.

Anaerobic digestion—Biological degradation of organic materials by micro-organisms in the absence of oxygen.

Back end recovery—Separation and recovery of materials from the residue of incinerated MSW.

Balance sheet costs—The direct costs of operating and owning a facility that reflect on the facility's accounts. Subsidies or externalities are excluded in this accounting.

Beverage delivery industries—all industries involved in the production and sale of beer and soft drinks-brewers, bottlers, wholesalers, distributors, and retailers.

Capacity utilization factor—The fraction of total plant capacity actually utilized over a period of time.

Capital gains tax—A tax levied on net income realized from the sale of a capital asset.

Capital stock—The undepreciated value of capital plant and equipment in place.

Centralized resource recovery—Centralized separation and recovery for use or recycling of materials and/or energy contained in mixed MSW. Facilities may range in capacity from 25 to 3,000 or more tons per day.

Char—A combustible, carbonaceous residue from the pyrolysis of MSW or other organic matter.

Cogeneration—Production of useful heat and electricity simultaneously in a single facility.

Coliforms-Relating to, resembling, or being colon bacillus.

Competitive—A market situation in which no producer or consumer alone is able to influence the prices at which goods and services are traded.

Compost—A mixture of decayed organic matter used for fertilizing land.

Conservation—Use of less resources (materials or energy) than would otherwise occur at the existing states of technology, prices, and institutions.

Cullet—Mixed, broken glass.

Decibel—A measure of the loudness of noise.

Depletion allowance—See percentage depletion allowance.

Deposit—A sum of money paid to a lender of a good by the borrower and refundable to the borrower upon return of the good.

Discard—An item that an owner no longer desires to possess, and which is made available for reuse, recycle, or disposal; also, the making available of such an item.

Discount—The assigning of a value in the present to the future value of an action or a good.

Disposal—The ultimate return of an item or product to the earth, through burial, dumping, combustion, or chemical reaction.

District heating—Provision of heat and/or cooling water to a number of users from a central source; usually, to several buildings in an urban area.

Economy of scale—A situation in which the average cost of producing a good or service declines as the rate of goods production or service delivery increases.

Eddy current—An electrical current induced in a material that is moving relative to a magnetic field.

Effectiveness—The degree to which a policy or program is expected to accomplish the objectives to which it is directed.

Effluents—Air or water pollutants emitted from a facility.

Elasticity of demand (or supply)—The percentage change in demand (or supply) that occurs if the price of a good or service changes by 1 percent.

Electrostatic precipitator—A device that uses an induced electrical charge and a magnetic field to recover fine particles from a flowing gas stream.

Epidemiology—The study of the relationships between the causes, occurrence, and control of disease in a population.

Equivalency (approach to ratemaking)—Setting equal rates to transport different batches of raw materials that are required to produce an equivalent amount of final product.

Ex parte—A legal proceeding approached from one side or one point of view only.

Externality-A cost or benefit of an economic activity not borne by a participant in the activity.

Extraction —Mining or other removal of a mineral resource from the earth.

Ferroalloy —Alloys of iron with certain other metals used in the production of steel.

Ferrous metals—Metals containing a high percentage of iron, including steels.

Fill—The provision of one container-full of beverage.

Filter cake—The solids collected in filtering a solid/liquid mixture.

Fire tube boiler—A boiler in which combustion gases pass through tubes immersed in water that becomes steam.

Float—The inventory of beverage containers and secondary packaging in circulation and storage that is required to support a refillable container system,

Flow control—Ordinances that require delivery of collected MSW to specific resource recovery or disposal facilities.

Frit—Partially fused materials of which glass is made; fused slag from pyrolysis.

Front end recovery —Separation and recovery of materials from mixed MSW prior to incineration or other thermal processing,

Froth flotation—Process of removing glass particles from a water slurry of mixed waste with chemicals that create a froth or foam in which the particles become entrapped and with which they can be skimmed off.

General obligation bonds—Municipal bonds whose principal and interest payments are met from and guaranteed by general revenues.

Glass aggregate—See aggregate.

Glass cullet—See cullet.

Heating value—The heat, or energy, released by combustion of a standard amount of fuel under specified conditions (higher and lower heating values refer to whether the water produced by combustion is available as liquid or vapor, respectively).

Heavy metal—Any of a class of metals of high atomic weight and density such as mercury, lead, zinc, and cadmium that are known to be toxic to living organisms.

Home scrap—Scrap material produced and reused within the same processing facility, such as a steel mill or copper smelter.

Humus—The organic portion of soil formed from partially decomposed plant or animal matter.

Hydrolysis—A reaction of an organic chemical with water to produce two or more chemical species that incorporate the elements of the water molecule.

Impact—Any outcome or result of an action, whether direct or indirect.

Incinerator bundle—Tin can scrap, compressed to charging box size and weighing not less than 75 pounds per cubic foot. Processed through a recognized garbage incinerator. (ISIS specification)

Investment tax credit—A deduction from corporate income taxes otherwise due, allowed in proportion to the amount of investment in some specified types of capital goods.

Job gain—Total (but not net) number of new full-time job equivalents created by adoption of a policy.

Job loss—Total (but not net) number of existing full-time job equivalents lost due to adoption of a policy.

Job shift—Net number of jobs created or lost due to adoption of a policy (job shift= job gains minus job losses).

Leachate—Contaminated ground water resulting from the passage of rain or surface water through a waste landfill or dump.

Loan guarantees—A program of Government-funded insurance to protect lenders against failure of a project to obtain sufficient revenues to pay back the principal and interest on a loan.

Long run—A period, usually of several years, during which capital equipment expenditures significantly reflect changing prices, demands, and policies.

Low-interest loans—A Government subsidy to lenders to allow them to offer loans for specific purposes at below market interest rates.

Manifest—Written documentation accompanying specific batches of material or of waste that identifies their origin and composition.

Marginal cost—The cost of producing one additional unit of output from existing plant and equipment (short-run marginal cost) or from additional plant and equipment (long-run marginal cost).

Market failure—Any deviation from an ideal market economy in which all actors have perfect information, all costs are internalized, and perfect competition exists.

Market share—The percentage of total consumption of beverages sold in each container type (consumption measured in physical volume units such as ounces or barrels).

Materials system—An abstract model of the production, use, and disposal of materials in society.

Modular incinerators—Small-scale incinerators that recover heat or hot water, often used in groups of two or more to achieve a desired plant size.

Municipal solid waste (MSW)—regularly collected solid waste from households, institutions, and commercial establishments.

Nonferrous metals—Metals other than iron and steel that are found in MSW, such as aluminum, copper, zinc, lead, and their alloys. (In analysis of MSW, aluminum is often treated as a separate component.)

Nonreturnable—Beverage containers designed to be used only one time.

Number 1 Bundle—New black steel sheet scrap, clippings, or skeleton scrap, compressed or hand bundled, to charging-box size, and weighing not less than 75 pounds per cubic foot. (Hand bundles are tightly secured for handling with a magnet.) May include Stanley balls or mandrelwound bundles or skeleton reels, tightly secured. May include a chemically detinned material. May not include old auto body or fender stock. Free of metal coated, limed, vitreous enameled, and electrical sheet containing over 0.5 percent silicon. (ISIS specification)

Number 2 Bundle—Old black and galvanized steel sheet scrap, hydraulically compressed to charging-box size and weighing not less than 75 pounds per cubic foot. May not include tin or lead-coated material or vitreous-enameled material. (ISIS specification)

Number 3 Bundle—Old sheet steel, compressed to charging-box size and weighing not less than 75 pounds per cubic foot. May include all coated ferrous scrap not suitable for inclusion in Number 2 bundles. (ISIS specification)

Obsolete scrap—Scrap recovered from used products including postconsumer scrap, demolition waste, railroad and other transportation scrap, etc.

Pathogens—A specific causative agent of disease such as a bacterium, virus, or fungus.

Percentage depletion allowance—A deduction from taxable income of a percentage of annual gross income arising from production and sale of certain minerals.

Pilot plant—A facility of size intermediate between a laboratory and a commercial plant used to test and evaluate a new product or process technology.

Postconsumer waste—Solid waste consisting of products used by final consumers (MSW, automobiles, but not industrial, demolition, or railroad waste).

Primary material—A bulk material of commerce produced from virgin raw materials.

Product charge—A tax or charge levied on bulk materials or final products designed to add the cost of their disposal to the purchase price.

Prompt industrial scrap—Scrap returned from fabricators of products directly to producers of materials, usually with a known composition and level of contamination.

Property tax abatement—A reduction in or exemption from payment of property taxes on specified classes of property over a specified time period.

Pyrolysis—Partial decomposition of organic material to gas and/or liquid in insufficient oxygen to support combustion.

Quad—1 quadrillion or $10'^5$ Btu or 1.055 exajoule of energy.

Recyclable—A solid waste material or product capable of being recycled.

Recycle rate—In connection with beverage containers, the fraction of containers distributed that is actually recycled into new metal or glass.

Recycling—Reprocessing of used products into new basic materials of commerce, in which the identity and utility of the original product are lost.

Recycling allowance—A direct grant or tax incentive from the Government to producers or users of recycled materials in proportion to some measure of the amount or value of recycled materials used.

Refractory particle—a ceramic particle or stone that does not melt at glass-making temperatures.

Refuse-derived fuel (RDF)—A solid fuel produced from MSW by removal of recyclable metals and glass and of refractory solids such as stones, ceramics, and metal particles.

Reliability-The anticipated fraction of time or fraction of capacity at which an item of equipment or plant is expected to operate successfully.

Resource recovery—Procedures and processes for recovery of useful energy and/or recyclable materials from mixed or segregated MSW. (Often restricted to centralized recovery from mixed waste, but more properly applied to all types of recovery for the purpose stated.)

Return rate—The fraction of all refillable beverage containers distributed that are actually refilled and redistributed.

Refillable—A container designed to be filled and distributed more than once.

Reuse—The use of a product two or more times without substantial change in form or function and without substantial repair or renovation.

Revenue bonds—Bonds sold to help pay for a project whose principal and interest payments are met from revenues of that project.

Sanitary landfill—A landfill operation that meets established standards for ground water quality; air pollution; site quality; vermin, pathogen, and disease vector control; and site renovation.

Scenario—A coherent depiction of one possible future development of trends and events.

Secondary material—A bulk material of commerce produced by processing postconsumer or other obsolete scrap.

Secondary packaging—A package designed for storage and transport of a number of individual beverage containers.

Severance tax—A tax on virgin materials levied at the point of mining or harvest in proportion to some measure of the amount or the value extracted.

Shelf price—The actual price paid by consumers for beverages, not including any refundable deposit or sales taxes.

Short run—A period of time of economic adjustment within which plant and equipment are not substantially modified or expanded.

Side effects—The unintended, indirect, or delayed effects of an action or policy.

Slag—A solid, heterogeneous inorganic mass formed from melting of materials in an incinerator or other thermal waste processor.

Source separation—Collection of waste products that are segregated according to material type by waste generators (a misnomer in that separation of mixed waste is not required—only maintenance of the original unmixed state).

Subsidence—A drop in the surface level of a covered landfill or dump that occurs as the contained waste decomposes and is compacted.

Subsidy—A direct or indirect payment from the Government to specific classes of citizens or institutions for the purpose of encouraging some activity which has been deemed to be necessary or desirable for the accomplishment of some policy objective.

Substitution—In an economic sense, the replacement of one factor of production with another to produce the same output at no change in total cost; often used more generally to denote the replacement of one raw material by another, at higher or lower total cost depending on the circumstances.

Tipping fee—the price charged for dumping MSW at a landfill or resource recovery plant.

Transfer station—A facility at which MSW is transferred from collection vehicles to large trucks or rail cars for long distance shipment.

Trip—One cycle in the utilization and return of a refillable beverage container.

Trippage—The average number of trips made by a refillable beverage container during its useful life.

Trommel—Rotating screen used in RDF systems to remove abrasive fine sand, glass, and frit from MSW; sometimes has larger holes to allow removal of containers and other objects of similar size.

Value-of-service —Basis for setting railroad freight rates in proportion to the value of the good shipped rather than the cost of providing the transportation service.

Virgin material—A raw material acquired directly from natural sources.

White ledger—Mixed, high quality waste paper typically acquired from offices.

Wet pulping—Separation of mixed MSW by intensive agitation of waste in a water slurry: organic fiber remains in suspension, heavy solids sink, and plastic film, string, etc. float and are skimmed off.

Waterwall incineration—Direct combustion of raw MSW, generally without preprocessing. The primary product is steam.

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