Chapter 3

The Marketability of Recovered Resources: Status and Policy Options

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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	$;	11
Other nonferrous metal	0.3	2	0.1	1.3

[a] From table 3.
[b] From RTC working paper One (l), 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[ource] 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.

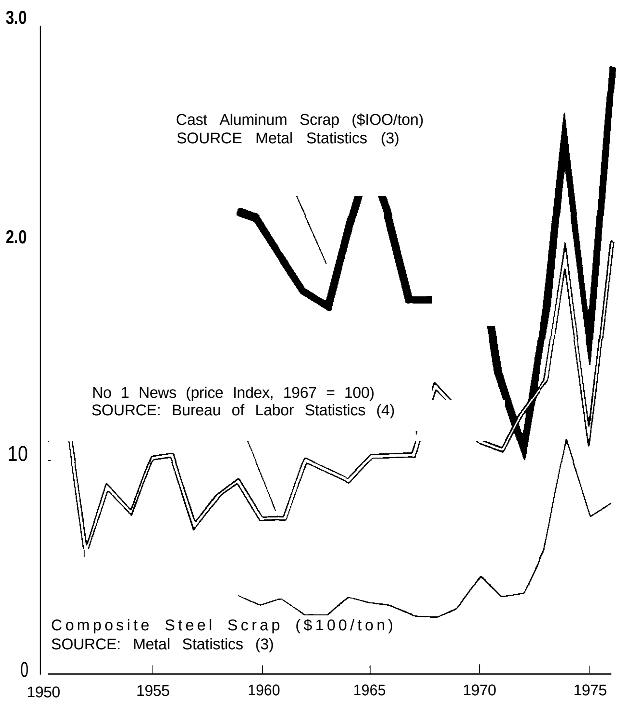
short hauls. Thus, the level at which freight rates are set influences whether some low-valued recovered products such as glass can be marketed at all.

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 ($/ton)			Potential revenue from recovered resources at the market[b]	Potential net revenues at average prices for various transport distances ($/ton of MSW)		
	Under 200 miles	200-400 miles	400-600 miles	($/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	o.14d	o.14d	o.13~
Aggregate	—	—	—	0.05	0	0	0
Total	—	—	—	5.25	4.08	3.59	3.00

aSource: Moshman Associates, Workln-g 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

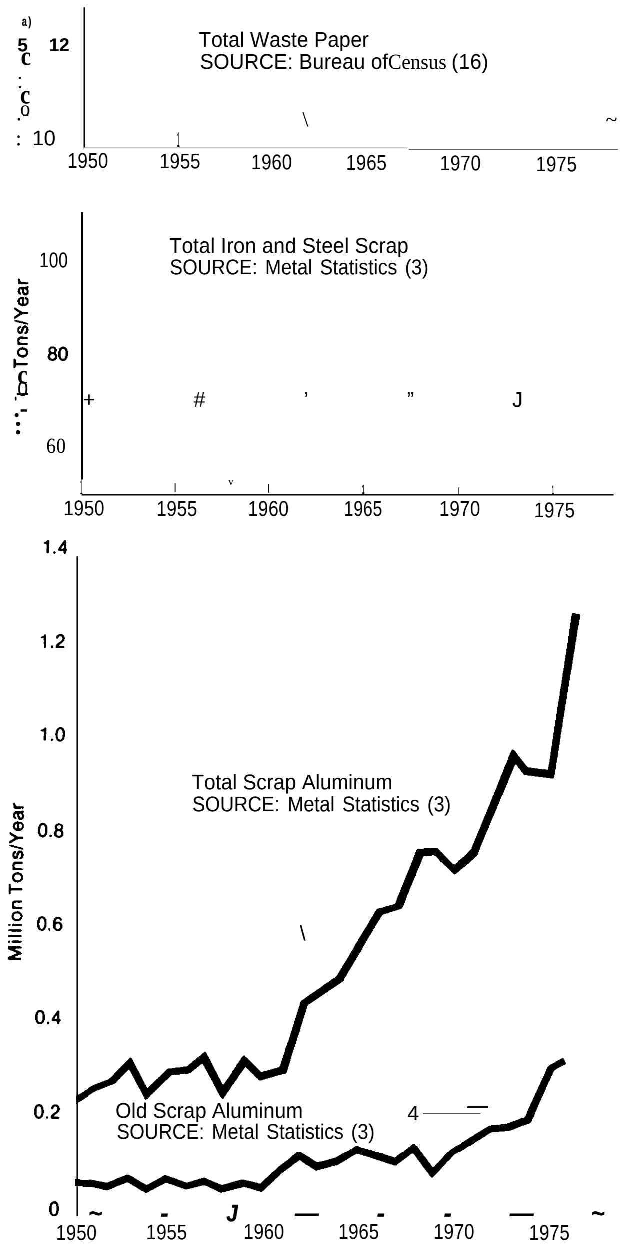
Aggregate derived from solid wastes consists primarily of small particles of glass, stones, bones, metal, ceramics, and plastics. It might be used as a sand or gravel substitute in road construction as well as in other concrete applications, and as a construction material in wall panels, terrazzo flooring, 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.

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

Secondary material type		MSW content as percent of counterpart scrap material traded
MSW component	Counterpart scrap material tradedb	
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	50,000C

aBased on 1975 gross discards In (18)
bBased on average of trade In 1973, 1974, and 1975 Data from Sources In. dicated
cEstimate based on data in (5)

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.

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 waste-paper. 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:

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

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/waste-paper 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

*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 % 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[a]: Variable cost	Fully allocated cost	Value of service	Equivalency
Iron ore/ferrous scrap	+	+	—	0
Bauxite/aluminum scrap. .	+	+	_(?)	–
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.

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