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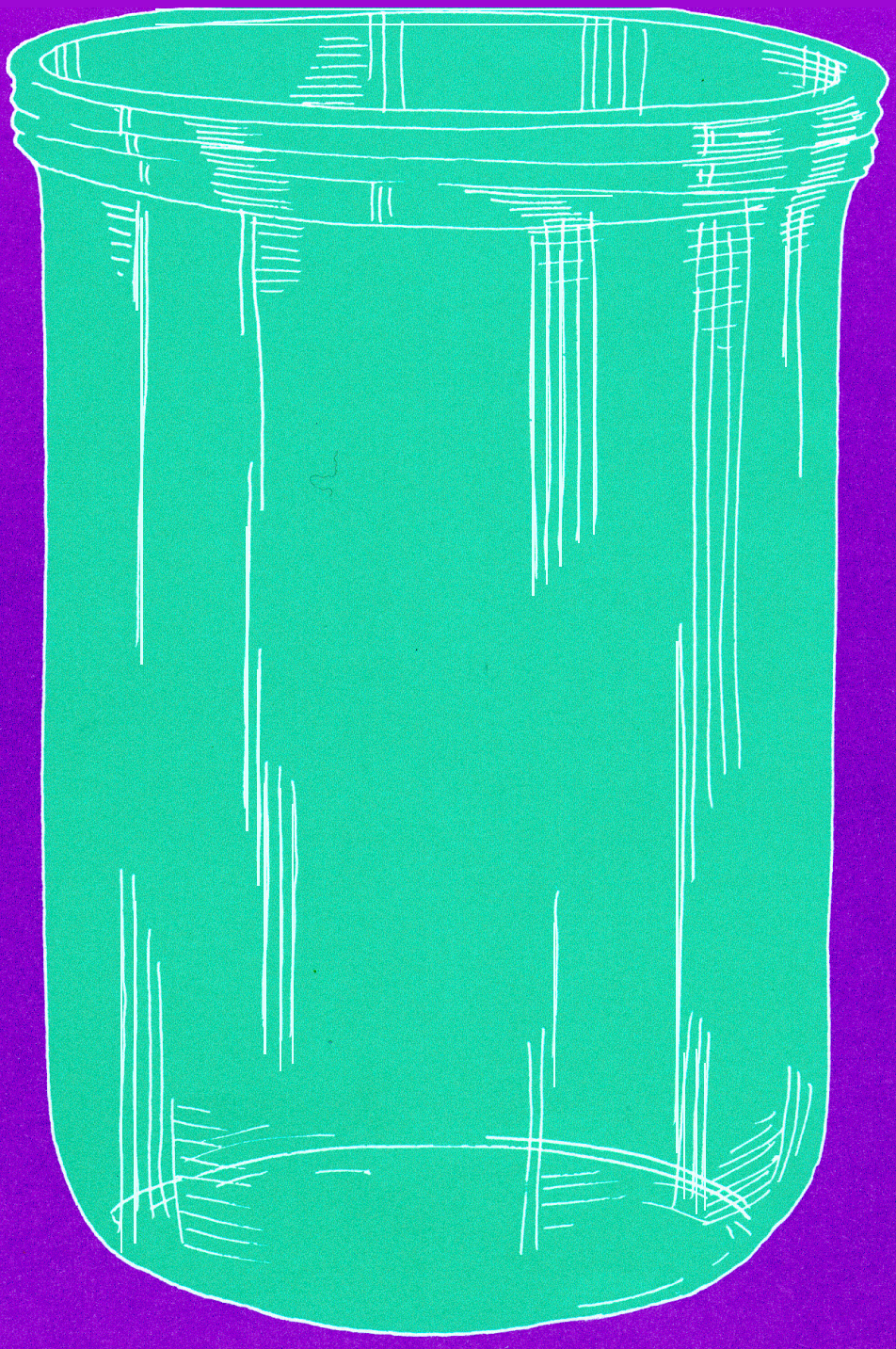
Markets for Recovered Glass



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I. Introduction

Recycling is experiencing a rebirth as the era of abundant, inexpensive landfills is coming to an end. In some parts of the country, landfill capacity is becoming strained by shutdowns at existing operations and difficulties in siting new operations. As a result, recycling, with its recognition of the intrinsic value of many of the materials that are thrown away, is becoming an economic and logistical necessity in many communities.

Yet the economics of recycling (as opposed to the economics of landfills) currently makes recycling attractive for only a limited number of materials. Used materials will be recycled only if they can be collected, processed, and reused at the same or less cost than substitutes made from virgin materials can be produced. Markets for recovered materials have developed over time to facilitate the consolidation of material into quantities that are worth handling and that allow for economies of scale in collection and processing.[1]

Because these existing markets are the key to continued and expanded recycling opportunities, governments contemplating initiatives for promoting recycling should consider the operation of these markets and how the markets would react to policies designed to increase recycling in the United States. Governments should understand the operations of the private sector in handling these materials; otherwise, policies that appear to promote expanded recycling opportunities may replace private ventures with government operations. In addition, governments should understand the influences of policy decisions on the scrap markets so that incentives designed to encourage reuse and recycling are targeted appropriately.

This study describes the operation of the markets for cullet, or crushed scrap glass. It concentrates on post-consumer cullet in the municipal solid waste stream, although it provides limited information on other glass as well. The study addresses the following issues:

- How the markets are structured
- What influences the supply of and demand for materials
- What projections can be made about the markets
- How government policies to increase recycling might affect these markets

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[1]Recovery refers to the supply to scrap material from, for example, households. Material collected from curbside collection programs is therefore recovered material, it is not considered recycled until the material has been processed and returned to a similar or some other use.

The market for glass cullet was chosen as the focus of this study because glass is an important component of the municipal solid waste stream, accounting for 7 percent of waste generation (by weight). The recycling discussion focuses on container glass, since container glass cullet represents virtually 100 percent of all glass recovered from the municipal waste stream.[2]

[2] U.S. Environmental Protection Agency. *Characterization of Municipal Solid Waste in the United States: 1990 Update,* June 1990, p. 15.

II. Market Overview

Scrap glass exists in three forms. Manufacturing scrap is a mixture of transition glass, off-specification glass generated as glass producers slowly change the ingredient mix in their giant melting vats, and finished glass that breaks at the manufacturing plant. Pre-consumer cullet is finished glass that breaks at a bottling or distribution facility. Both of these types of scrap are reused within the glass plants. Finally, post-consumer cullet consists of the glass bottles or other glass products discarded by consumers after use.

Glass is 100 percent recyclable in that it can be melted repeatedly to produce the same product, and the technology for recycling glass is relatively simple and well established. The reuse of cullet is complicated, however, by the fact that different types of glass are not always compatible for recycling. The glass produced by different manufacturers differs in both form and chemical composition. Form variations are familiar: glass comes flat, pressed and blown into shapes, or in more complicated applications, such as fiberglass or fiber optics. Although glass can be remelted and changed from one form into another with ease, a problem arises in separating the glass from other materials in a product (e.g., separating the glass in a light bulb from other non–glass components). Glass also differs in chemical composition. Although all glass is composed of silica and sodium oxide (soda ash), the type and quantity of other compounds added vary slightly in different types of glass. These differences frequently cause problems in recycling glass, because producers of some types of glass have strict specifications for the chemical makeup of any cullet they might use. However, as discussed later, there is evidence that these requirements maybe more flexible than is frequently perceived.

Glass in the Solid Waste Steam: The Source of Post-Consumer Cullet

The amount of glass discarded into the municipal solid waste stream (discarded glass equals total glass generation minus material recovery) declined from 14.2 million tons in 1980 to 11.0 million tons in 1988. Virtually all of this glass is post-consumer glass. The total weight of discarded materials grew 15 percent during that period, and so the percentage of discarded material represented by glass fell from 10.5 percent in 1980 to 7.1 percent in 1988.[3] The decline in the percentage of the waste stream accounted for by glass may be explained by several factors. First, in recent years the packaging industry has shifted away from the use of glass in packaging to the use of aluminum and plastic, As glass containers represent a large component of all glass

[3]U.S. *EPA, characterization of Municipal Solid Waste in the United States: 1990 Update,* June 1990, (USEPA 1990) pp. 12, 15.

discards (89 percent by weight in 19884), this translates into a measurable decrease in the total volume of glass discards. Second, an increased effort is being devoted to recovering glass through state and local legislation (e.g., mandatory recycling laws or deposit laws) and through alternative government or industry–run recovery programs.

According to a recent EPA report, 1.5 million tons of glass, or 12 percent of total glass waste generation, was recycled in 1988. Glass cullet from bottles and jars represents virtually 100 percent of this recycled material. In 1988, 73 percent of the recycled glass cullet was derived from beer and soft drink containers, while the remaining 27 percent came from wine, liquor, food, and other glass containers.[5] This mix represents a change from the historical composition of cullet. In the past, beer and soft drink containers accounted for virtually 100 percent of recycled container glass.[6] Since 1985, however, the expansion of curbside and drop-off recovery programs has encouraged the recovery of other types of glass containers, resulting in the present cullet mix.

Container Glass

Most glass (89 percent) that is discarded is container glass. The glass container industry is also the largest segment of the glass industry, shipping $4.5 billion dollars worth of glass containers in 1989[7] and employing about 43,2008 workers. In 1987, glass containers represented 44 percent of the value of primary glass shipments in the United States.[9] Glass containers are used in a variety of product industries, including food and beverages, medicine and health, toiletries and cosmetics, and chemicals.

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[4]Ibid., p. 15.

[5]Ibid., p. 15.

[6]Ibid., p. 44.

[7]W.S. Department of Commerce, U.S. *Industrial Outlook 1990.*

[8]Predicasts, Inc., *Predicasts' Basebook, 1989,* p. 500.

[9]This figure is derived using the sum of the value of product shipments for SIC codes 321 and 322. Other glass products (e.g., SIC 3231, Products of Purchased Glass) are manufactured using glass produced by industries with SIC codes 321 and 322. Source: U.S. Department of Commerce, Bureau of the Census, 1987 *Census of Manufactures, Industry Series: Glass Products.*

The decline in the amount of container glass discarded (dropping from 13.2 million tons in 1980 to 9.9 million tons in 1988[10]) is largely attributable to a decrease in the shipment of new glass containers, from 46.7 billion units in 1980 to 40.5 billion units in 1988.[11] The decreased shipments reflect the industry's loss of market share to other container types. (See Chapter III.) According to the Glass Packaging Institute, the trend toward making lighter bottles also contributed to a decrease in the weight of glass in the solid waste stream.

In 1989, however, product shipments of glass containers grew slightly for the first time since 1986, to 40.9 billion units. Growth in 1989 shipments is attributed to various factors, including the conversion from plastic soft drink bottles back to glass in a few markets, increases in sales of beer and food containers, and deceleration in the movement to plastic bottles for liquor products. [12]

Throughout this same time period, the recycling of glass containers has increased. In 1980, 5.7 percent of glass containers were recycled. By 1988, this rate had increased to 13.3 percent of glass containers, representing an increase of 133 percent. Materials recovery from the entire solid waste stream increased at a slower rate, from 9.7 percent in 1980 to 13.4 percent in 1988, or an increase of 38 percent.[13]

Some of the impetus for increased recovery of glass containers has come from deposit laws or bottle bills. In 1970, no bottle bills existed; in 1988, nearly 44 million Americans (18 percent of the U.S. population) lived in the nine states that required deposits on glass beer and soft drink containers. Recycling programs initiated by states, localities, or industry have also helped boost the recovery rate for glass containers. Reliable data on the source of recovered glass containers are not available, however.

Recovery of glass in 1988 totaled 1.5 million tons (12 percent of total glass generated); most of this was beer and soft drink containers (1.1 million tons). (See Table II–l.) Growth in curbside and other recycling programs in the last several years has also increased the quantities of other types of glass recycled. In 1988, other container glass and non–container glass accounted for approximately 27 percent of the total glass recycled, compared with less than 1 percent of all glass recycled in 1986.[14]

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[10]U.S. EPA 1990, p. 46.

[11]U.S. Department of Commerce, *U.S. Industrial Outlook 1985, 1990.*

[12]Ibid.

[13]U.S. EPA, pp. 44-45.

[14]US. EPA, *Characterization of Municipal Solid Waste in the United States, 1960 to 2000 (update 1988),* March 30,1988, pp. 21,22.

Table 11–1

Glass in Municipal Solid Waste 1988

Type of Glass	Glass Generated		Glass Disposed		Glass Recovered	
	Tons	Percentage of MSW	Tons	Percentage of Generation	Tons	Percentage of Generation
Container Glass	11.3	6.3%	9.8	86%	1.5	14%
Beer and Soft Drink	5.4	3.0	4.3	80	1.1	20
Other (e.g., food)	5.9	3.3	5.5	93	0.4	7
Non-Container Glass	1.2	0.7	1.2	≥92	≤0.1	≤8
All Glass	12.5	7.0%	11.0	88%	1.5	12%

Note: Tonnage figures are in millions.

Source: EPA, 1990, pp.15, 42-48.

Non-Container Glass

Details on the composition of the non-container segment of glass in the solid waste stream are extremely sketchy, as no quantitative data exist to describe it. Non-container glass amounting to 1.2 million tons were discarded to the municipal solid waste stream in 1988, although this figure is probably underestimated. [15] Presumably, this figure includes disposal of broken windowpanes, windshields, glassware, and other durable glass products thrown away by residential consumers. Because of the diversity of non–container glass and the fact that no component of the total is very large, "materials flow" methodology does not capture the recovery and disposal trends of this glass very well.

It is estimated that little of the non-container glass in the municipal solid waste stream is recovered. Non-container glass is recovered from commercial and industrial waste streams, but no comprehensive data exist on non-container recycling.

[15] U.S. EPA, p. 15.

One major industrial recycler estimates that about 500,000 tons of plate glass are recovered each year. This glass comes not only from communities, but also from industrial and commercial sources. In addition, in–house recycling occurs in all the glass industries.

Final Consumers of Cullet: The Demand Side of the Market

Just as the glass container segment is the largest single component of the glass industry, glass container manufacturers are by far the largest users of post-consumer cullet. Although other glassmakers and users of purchased glass use cullet in their production processes to some degree, no other market for cullet is as important currently as the container market. The extent of cullet use in an industry depends on transportation costs, technical requirements, and public relations considerations. Each of these factors will be discussed in more detail in Chapter III.

Container manufacturers have a strong interest in buying uncontaminated post-consumer cullet as a raw material for production. Although little information is available on the cost savings from using cullet instead of virgin materials, we have cited below savings in energy use and extended furnace life as two benefits. Also, given increasing public and governmental pressure on the content of packaging, it is in the industry's best interest to use as much recovered material as possible in its products.

Glass Containers

According to the Bureau of the Census, glass container manufacturers consumed about 830,000 tons of cullet in 1982.[16] Recent informal estimates of cullet usage in the container industry put cullet consumption above 1 million tons per year, but the industry has no official estimate of cullet usage. Unfortunately, the Census statistics do not distinguish between pre- and post–consumer cullet, but the container industry's 830,000 tons is the largest share of total cullet reported. If we include cullet use in containers (830,000 tons), pressed and blown glass (96,000 tons), products of purchased glass (207,000 tons), and flat glass (506,000 tons using 1977 data), total usage was roughly 1,600,000 tons. This includes pre-consumer cullet, transition glass routed back into the batch, and post-consumer cullet.

Even though limited data makes it impossible to quantify, the container industry's stake in glass recycling is substantial. To process cullet before remelting, container manufacturers own and operate 27 beneficiation (cleaning and processing) units, which service the industry's 82 manufacturing plants. The industry also supplements its

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[16]U.S. Department of Commerce, Bureau of the Census, *1987 Census of Manufactures, Industry Series: Glass Products.* Data from the 1987 Census of Manufactures do not contain revised estimates of cullet use, since a large fraction of the total had to be estimated.

cullet supply by purchasing furnace-ready cullet from independent dealers and processors.

The major consideration in recovering cullet for use in the container industry is contamination. Contaminants include containers of a different color (such as a green bottle in a pile of clear glass cullet), metal caps and neckrings, and ceramics. It is important for container manufacturers to remove these contaminants before the cullet enters the production process. Since the container industry produces green, amber (brown), and flint (clear) containers, color sorting at the point of collection is one way in which producers minimize contamination. The technical specifications for each color require cullet to be color–sorted if it is to be used in significant quantities, particularly in the manufacture of flint containers.

According to glass container industry representatives, except as discussed below, the container industry is willing to buy as much cullet as it can get if it is free from contamination (e.g., ceramics) and color–sorted. Cullet has several advantages over virgin materials in the container industry. Each 10 percent of the batch displaced by cullet saves 1 to 5 percent of the energy used to make virgin glass. [17] In addition, using cullet may extend the life of the glass furnace due to the lower temperatures needed to melt the cullet, and can give a marketing advantage to firms that use it for consumer products. Furthermore, although greater effort has been put into recovering glass, recovery rates are still low; as a result, the supply of flint and amber cullet is short.

Green cullet is the one color that is not in very short supply, say industry representatives. In fact, serious gluts of green glass have occurred because of low domestic green glass manufacturing capacity and a large volume of imported green glass containers (e.g., beer and wine bottles).

There are some short-term technical limitations on cullet use. According to container manufacturers we spoke to, most plants would require modifications to operate using greater than 50 percent cullet, but the modifications are technically possible. Although some plants are currently using cullet at or above the 50 percent level, most of the container industry has a "batch percentage" in the 20 to 30 percent range. Because the furnaces run continuously and must be set for a given mix of cullet and other inputs, the plant operator must be sure there is sufficient cullet to maintain the feed rate. Since cullet supply (i.e., recovery from households and others) has been somewhat uncertain, it is prudent to plan conservatively for the batch percentage. With more supply becoming available through curbside and other programs, batch percentages will likely increase, especially at plants near major supplies (i.e., near population centers with active recovery programs).

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[17] Gordon Stewart, "Cullet and Glass Container Manufacture," *Resource Recycling,* March/April 1986. According to Nancy A. Lang ("Hoisting the Glass," *Beverage World,* June 1989), fuel makes up 15 percent of the cost of producing virgin glass. Thus glass using 10 percent cullet has a 0.15 percent (15 percent of 1 percent savings) to 0,75 percent (15 percent of 5 percent savings) cost advantage over virgin glass, not including the difference in price between cullet and virgin materials.

Cullet prices do not vary over time as much as other commodity prices. Cullet-handling firms interviewed, as well as officials from state and local governments, report that prices stay fairly steady. Several cullet sellers interviewed reported that prices they received had "always been" in the $40 to $45 per ton range. Others quoted higher or lower prices based on location or glass color, but individual marketers typically do not experience wide fluctuations in the price they receive for cullet. We were unable to identify data sources showing cullet prices over an extended period, however.

Cullet prices vary depending on the color of the glass and the region in which it is sold. Because of the prevalence of clear glass containers in production, demand (and price) for clear or flint cullet is generally stronger. Less green and brown glass are manufactured domestically and imported colored glass provides additional supply which weakens prices. Regional differences result primarily from transportation costs.

Table II–2 shows recent cullet prices, taken from the August 13, 1991, issue of Recycling *Times*, for three color types in seven regions of the United States. These data show that, while end users (glass manufacturers) are paying $0 to $15 per ton for green glass cullet in the Northeast, the price for the same cullet in the South Central states is $50 per ton. Smaller price differentials exist within some regions for different colors of glass. For instance, in the Northeast, green cullet sells for $0 to $15 per ton to end users, while clear cullet sells at $43 to $50 per ton. In the South, green cullet sells for $10 to $20 per ton versus $50 per ton for clear cullet. These price differences affect the price municipalities and private collectors receive for their cullet, even though the price to those municipalities and collectors does not fluctuate greatly over time. A nationwide study published by the Glass Packaging Institute, in which 19 communities with recycling programs were surveyed, reported cullet prices ranging from $25 to $66 per ton.[18] Further discussion of price variations is presented in Chapter III.

[18]Glass Packaging Institute, *Comprehensive Curbside Recycling, 1988.*

Table II-2

Cullet Prices Paid by Glass Manufacturers by Region and Color

(dollars per ton)

Cullet color	Northeast	Mid-Atlantic	South	South Central	East Central	West Central	West*
Clear	*$43-50*	*$50-55*	*$50*	*$50*	*$40-55*	*$50*	*$60*
Brown	**20–25**	**45–55**	*50*	*50*	*22-25*	*50*	*60*
Green	**0–15**	**1 0–20**	**1 0–20**	**50**	**0-15**	*50*	*60*

•Price includes California scrap price which is subsidized by the glass packaging industry in the state; the subsidy is a response to California's container recycling law, **AB 2020**

Source: Recycling Times, August 13, 1991. Prices cover July 15 to August 2, 1991.

Consumption of Cullet by Non-Container Glass Producers

The use of cullet in the non–container class industries varies greatly. Some industries, such as the fiberglass insulation industry, use a small amount of cullet in their manufacturing processes. The glass bead industry uses a significant amount of cullet according to the Glass Packaging Institute. Other industries, such as the producers of many kinds of pressed and blown glassware, purchase no cullet and in fact sell their own scrap. Producers of non--container glass more commonly use small amounts of cullet which are mostly self–generated and rarely purchased. As mentioned earlier, however, we could not find reliable data on cullet usage in these industries.

In part, the reluctance in many glass industries (other than glass container manufacturers) to use cullet stems from technical requirements. Container glass is not suitable for some glass industries because of differences in chemical composition between container glass and non–container glass. Differences in color may also cause technical problems. Some of this reluctance may also result from a stigma attached to recycled glass. Prior to 1970, most glass container manufacturers limited their use of cullet either in the belief that recovered glass was not as reliable as other glass or in the belief that consumers would not accept glass made partly from recovered materials. For some firms, such as a fiberglass reinforcements company we interviewed, there is no economic advantage to using cullet now, so they are not interested in doing so. However real or imaginary the barriers to cullet use, the result has been low use of scrap in industries other than the glass container industry.

The fiberglass insulation industry is one example of a non-container industry that faces quality constraints on the amount of cullet they can use. While some fiberglass insulation manufacturers use pre–consumer cullet from a variety of glass manufacturing processes, post-consumer cullet is less feasible because of its

inconsistent quality. The major requirement for using cullet in fiberglass insulation is consistency; fiberglass manufacturing is more sensitive than container manufacturing to contaminants and to differences in the composition of the glass. This sensitivity has been the limiting factor in the use of post-consumer cullet. In addition, bottle cullet does not contain boron, the key (and most expensive) ingredient in fiberglass. Thus, the materials cost savings for using post-consumer cullet are less for fiberglass makers than for container manufacturers. In addition, energy savings in this industry are not as great as in container manufacturing — each 10 percent of the batch displaced by cullet saves 1 to 3 percent of the energy used to make virgin insulation.[19] By comparison, container manufacturers realize an energy savings of 1 to 5 percent for every 10 percent of cullet.

"Glasphalt" is another commonly cited potential use for cullet, although it is not yet in widespread use. Several communities have tested this mixture of glass cullet and asphalt, which is used to pave roads. These communities, in tests using from 20 to 40 percent cullet in the glasphalt, found several disadvantages to the mixture. Using glasphalt actually increases the initial cost of paving by 25 to 40 percent.[20] In addition, traction is not as good on glasphalt as on asphalt at speeds above 40 miles per hour, and "rutting" may occur in the road when studded tires are driven over the glasphalt. Finally, "stripping," the appearance of loose grains of glass on the road, occurs in the first few weeks after paving. These problems are weighed against the advantage that glasphalt dries faster and retains heat longer than asphalt.[21] Glasphalt may also provide a low–cost outlet for mixed–color cullet. Also, on residential streets, problems with traction may not be as serious as on roads with higher speed limits. In any case, more widespread use of glasphalt will probably be required to verify and generalize the experience of the few communities that have tested the mixture.

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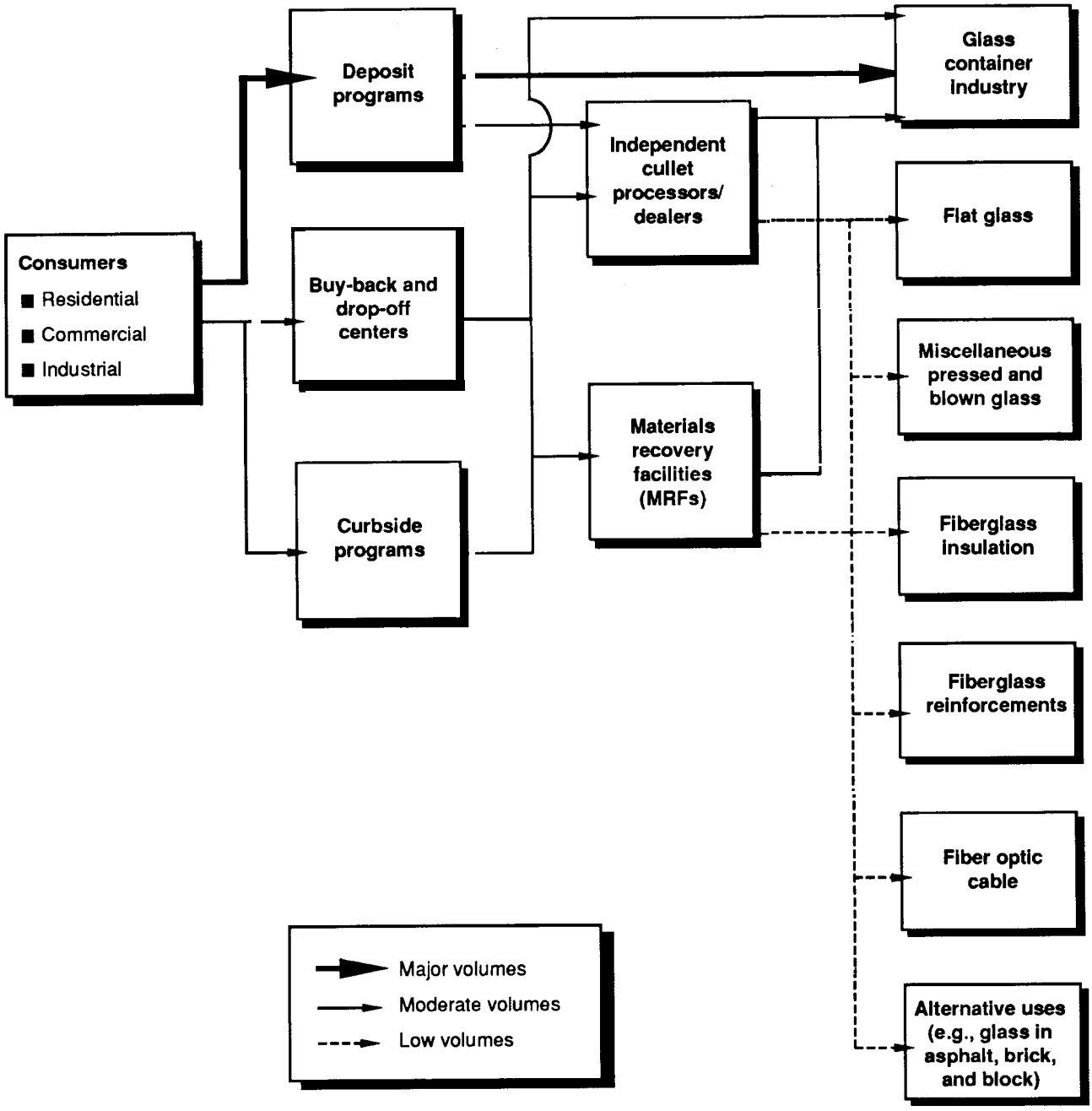
[19]"EPA Insulation Guideline, Part 3," *Waste Age,* June 1989.

[20]Personal Communication, John Rugg, National Pavement Asphalt Association, August 1990,

[21]Tom Watson, "When the Tire Hits the Glasphalt," *Resource Recycling,* July 1988.

Figure II–1

The Post-Consumer Glass Recycling Path



The Post-Consumer Glass Recycling Path

Post-consumer cullet can follow any one of a number of paths from the original glass consumer to the eventual end use. (See Figure II–l.) Several options exist for collecting post-consumer glass. In addition, cullet may go through an intermediary for processing before it is passed on down the recycling path. Finally, although most post-consumer cullet is eventually consumed at glass container plants, a small portion of the cullet may end up being used by other types of cullet consumers.

Collection

Glass containers are collected from consumers through three primary channels: deposit programs, programs involving drop-off or buy–back centers, and curbside pickup. No estimates of the quantity of cullet obtained from each of these sources exist. Deposit programs, as mentioned above, operate in nine states with a total population of 44 million people (18 percent of the U.S. population). Under these programs, consumers pay a minimum deposit of 5 cents (Michigan has a 10 cents deposit) on all beer and soft drink containers, including glass bottles.[22] Many of the deposit programs include wine coolers, two include wine and liquor bottles, and one includes juice bottles. The beverage industry also sponsors drop-off or buy–back centers in a number of states. Through these programs, consumers can return or sell their containers back to major glass–container manufacturers without having the glass pass through any intermediary. Finally, source separation with curbside pickup is an emerging method of collecting glass without imposing the inconvenience of transporting glass to a retailer or recycler. In this case, municipalities or private haulers collect the glass and sell it either to a container producer directly or to an intermediary.

[22]In California's deposit-type program (AB 2020), the redemption payment by distributors is 2 cents per container, and 4 cents per container of 24 ounces or more. The refund value is 5 cents for every two containers, and 5 cents per container of 24 ounces or more.

Reliable data on the amount of glass recycled by each method are not available, but we believe that deposit programs probably provided the largest fraction of container cullet in 1988.[23] Although deposit programs primariIy focus on beer and soft drink container glass, the California program, drop-off centers, and curbside programs accept all types of glass containers. While the data cited earlier indicate that most glass recycled from municipal solid waste is from beverage containers, the growth of these other glass recycling programs in the past several years suggests that a broader range of glass containers is currently recycled. Data from California's Division of Recycling indicate that for the last six months of 1988, 566 million glass beer and soft drink containers were recycled (207 million of which were refillable bottles), as well as 138 million other glass containers, including juice and food containers.[24] No national data exist describing glass recycled through drop-off and curbside programs, however.

Intermediaries/Processing

Most cullet must be processed in some fashion before it can be remelted and made into new glass. Cullet processing typically occurs in one of three types of facilities: a beneficiation plant installed at a container manufacturing plant, an independent intermediate processor, or a materials recovery facility (MRF). These three types of processing share two major common features. First, all have systems to remove contaminants and crush glass. Second, the three types of processors are regional in scope, with each facility handling over 10,000 tons per year and serving more than one container plant.[25]

Frequently, glass container plants can process the cullet themselves at one of the 27 beneficiation units in the United States. Most of these 27 beneficiation units have the same basic design. The beneficiation unit can process 15 to 20 tons of color–sorted glass per hour.[26] The system removes contaminants such as paper, plastic, or metal from the glass, and crushes the glass. These units could run virtually around the clock, given adequate cullet supplies. For comparative purposes, we calculated the processing capacity of these 27 units. Given a unit running 24 hours per day 7 days a week for 45

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[23]We can arrive at a rough estimate of glass returned through deposit programs using previously cited information. The Department of Commerce reported 150 million gross beer and soft drink containers shipped in 1988. If we assume that 18 percent of the population living in deposit states buy 18 percent of those bottles, then 3.9 billion bottles were sold in those states. Assuming a comparatively high return rate of 85 percent, about 3.3 billion bottles could have come back in those states. At an average of two bottles per pound, this works out to recovery of about 825,000 tons of glass, or slightly over one-half of the U.S. EPA estimate for 1988.

[24]California Division of Recycling, *Biannual Report on Redemption and Recycling Rates: July 1, 1988 to December 31, 1988,* pp. 5,8.

[25]Steve Apotheker, "Glass Processing: the Link Between Collection and Manufacture," *Resource Recycling,* July 1989, p. 38.

[26]Ibid., p. 41.

weeks, these *27* plants could process over 4 million tons of cullet each year.[27] It is estimated that the total for glass recovery by all facilities was 1.2 million tons in 1988. Since beneficiation units are running at or near capacity at many plants and glass is also processed by other intermediaries as well, these data suggest either that this estimate is too low or that glass recycling has increased substantially since 1988.

Alternatively, the cullet maybe processed by an intermediary that buys the glass from the collector, processes it into furnace-ready cullet, and sells it to a glass manufacturer. These intermediate glass processors, until recently, handled pre-consumer scrap caused by breakage at manufacturing and distribution plants. Now these processors are beginning to become involved in post-consumer scrap as well. An average processing plant costs $300,000 to $500,000 to build and has a capacity of 10 to 25 tons per hour.[28] Although the number of intermediate glass processors is unknown, the largest such company, the Cleveland–based Bassichis Company, operates 17 plants. We were unable to find reliable data on the total number or capacity of these intermediate processors.

Materials recovery facilities (MRFs) operate in areas where a high volume of post-consumer recycling makes it economical to separate types of recyclable (paper, metals, glass, plastic) and to process recycled glass at the same facility. MRFs typically separate glass from other recyclable through a combination of hand sorting, magnets and/or density separation. Glass is then color–sorted by hand or by machine. The last step resembles the processing done at a beneficiation plant. The cost and capacity of these systems vary, with capital costs per ton of daily capacity ranging from $10,000 to $75,000 per facility, and capacities anywhere between 8 and 300 tons per day. A recent survey put the number of MRFs operating or planned at 99, with 47 currently accepting recyclables.[29]

In addition, dealers perform the function of purchasing cullet from a number of relatively small collectors and then selling a much larger amount of cullet to a glass manufacturer. According to the glass container industry, one of the biggest problems in increasing cullet use in the container industry is the difficulty of guaranteeing a steady supply of cullet. Because glass producers can only change the proportion of ingredients in their vats slowly, they may use less cullet in the production process to guarantee that they will always be able to purchase enough cullet. Dealers can help guarantee a steady supply by grouping small collectors together.

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[27]Since glass furnaces typically operate around the clock, these units could also operate constantly to provide raw material.

[28]Apotheker, p. 40.

[29]Jim Glenn, "Fast Pace for MRF Development," Biocycle, May 1990.

Summary

The technology for recycling container glass is relatively simple and well established. Mechanisms for recovering glass from the municipal solid waste stream exist in many areas and include beverage container deposits, buy–back or drop-off centers, and curbside collection programs. Deposit programs focus on beer and soft drink containers, and, in some states, include wine coolers, wine, liquor, and/or juice containers. Estimates prepared for EPA suggest that beer and soft drink containers accounted for the majority of cullet recovered from municipal solid waste in 1988. Other programs, which are expanding, focus on a broader range of glass containers. Unfortunately, no comprehensive data exist to document the total quantity of post-consumer cullet that is collected. Finally, the little information available indicates that post-consumer non-container glass is rarely recycled because of the absence of collection mechanisms and the technological difficulties in reusing non-container glass and in separating other materials from the glass.

III. Factors Influencing the Cullet Markets

We have divided our consideration of issues affecting the cullet market into those that affect the supply of recovered cullet and those that affect demand for recovered cullet. For each side of the market, we will present issues that shape the supply of or demand for cullet, discuss trends in the industry that will influence the markets in the future, and present conclusions, which include our assessment of the ramifications of our findings for government policies.

Supply of Cullet

The supply side of a market reflects the costs of producing a given output. For the cullet market, the supply function can be thought of as the relationship between the price of cullet deliveries to glass manufacturers and the amount of cullet that suppliers are willing to deliver for that price. In most markets, suppliers are willing to provide some small quantity even at low prices. However, suppliers generally respond to higher prices by increasing the quantity they supply.

The major factor affecting the supply of cullet is the increasing attention being paid to recovery by consumers; the federal, state, and local governments; the media; and industry. Escalating landfilling costs will continue to lead to greater efforts to provide convenient recovery opportunities for glass, increasing the supply of cullet. Expanded recovery through curbside and drop-off programs will also increase the supply of container cullet not tied to deposit laws. We expect the quantity of cullet supplied to increase over the next few years.

Factors Influencing Supply

The major factors we have identified are summarized below. The text that follows describes these issues in more detail.

- Nonprice motivations for supplying cullet are important, particularly because the historical market price of cullet is low on a per bottle basis.
- The influence of public attention to recycling, an expansion of convenient recycling opportunities, and the prospect of higher landfilling costs should increase the supply of cullet.
- Regional differences in the supply of cullet exist because recycling is concentrated in certain regions, and because the cost of transportation limits the effective range of cullet sales.

Nonprice Motivations Affect Consumers' Decisions to Recycle Containers

The existence of drop-off centers where consumers, in effect, donate their containers by dropping them off without getting money back shows that the desire to "do good" is an important motivation to recycle glass. The economic motivation for consumers is weakened by the low price of cullet relative to the cost incurred in supplying cullet and the low cost of alternatives to recycling (e.g., land disposal). Currently, the scrap value of a typical glass beverage bottle is almost a penny and a half (assuming $50 per ton and an average of two bottles per pound). In areas that rely on drop-off or buy–back centers to collect used glass containers, the low price paid does not provide a strong incentive to consumers to return their containers. One study estimated that the return on a consumer's time spent in preparing bottles for return was about 4 cents per minute, or $2.40 per hour.[17] Consumers may be more influenced by the perception that donating used glass is an inexpensive way to contribute to a charity, or that recycling glass is an easy way to help the environment.

Monetary return does play some part in consumer willingness to recycle glass. Our rough analysis of 1988 data described in Chapter II suggests that the nine states with deposit laws were recycling more than half the total glass beer and soft drink containers recycled in the United States, a significantly larger share per state than contributed by non-deposit states. To achieve this response, however, the deposit states have had to offer returns on bottles that are far above the market scrap value of the bottle and we have not considered the cost associated with deposit laws.

The experience with price and nonprice motivations to recycle has been limited to a certain range of prices. In deposit states, a deposit of 5 to 10 cents stimulates the quantity of glass containers recycled. Elsewhere, the return to consumers is lower, despite the efforts of some large manufacturers of glass containers to subsidize container returns. For instance, California's Glass Recycling Corporation, formed by container manufacturers in the state, subsidizes container returns in order to prop container prices above a state–mandated minimum. [18]

Finally, we have not considered the entire benefit to society of recycling. Land disposal may be underpriced implying that recycling yields significant benefits beyond those currently recognized.

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[17]Darlene Snow and Ballina Edwards, *Glass Recycling: Opportunities and Constraints*, August 1985.

[18]The scrap price subsidy has been paid to avoid a processing fee which could be levied against all glass containers sold. The processing fee, established by AB 2020, is designed to ensure that recyclers earn enough to cover their costs plus a reasonable profit.

Deposit Programs May Focus on Only a Limited Share of Containers

As cited in the previous chapter, the majority of all post-consumer recycled glass in 1988 came from beer and soft drink containers. This is a result of the deposit laws in nine states and other recycling programs. Deposit programs, in most cases, establish deposits and provide return opportunities for soft drink and beer bottles only, which represent about 58 percent of containers sold.[19] Due to the limited focus of these deposit programs, recycling rates for other container glass and non-container glass have been relatively unaffected by deposit laws.

In other areas, any glass container can be dropped off at a center or put out for curbside collection. Most buy–back and drop-off centers accept non–beverage containers or even non–container glass. Given the growth of these non-deposit programs, especially those providing curbside pickup, we would expect a shift away from the dominance of beer and soft drink containers in the national recycling statistics.

Glass Containers Face Competition from Aluminum and Plastic

Since the introduction of plastic beverage containers in the late 1970s, the glass share of the beverage container market, as well as the non–beverage container market, has dropped consistently. Prior to that, glass was also losing market share to aluminum cans. In the soft drink market, for example, glass containers accounted for 80 percent of packaged soft drink sales in 1970. By 1980, the glass share had fallen to 45 percent and in 1989 it was 22 percent.[20] arket factors have favored growth for aluminum and plastic. Both materials are lighter than glass and both are shatterproof. Aluminum cans have captured a large share of the convenience market and the larger plastic containers have created a substantial market for at-home consumption.

Competition from plastic and aluminum has translated into a decline in the real value of glass container shipments every year from 1977 to 1987.[21] The number of containers shipped also declined between 1980 and 1988.[22] However, in

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[19]U.S. Department of Commerce, *U.S. Industrial Outlook 1990*, p. 11-1.

[20]National Soft Drink Association, 1986 *Statistical Profile and Beverage Industry Annual Manual 1990/91*, p. *72.*

[21]Predicasts, Inc., *Predicasts' Basebook, 1989,* p. 501.

[22]U.S. Department of Commerce, *U.S. Industrial Outlook 1989.*

1989, product shipments of glass containers grew slightly; this growth trend is expected to continue in the 1990s.[23]

The competition from other materials has meant that fewer glass containers are shipped and less glass is available for recovery and recycling: estimated shipments of glass containers in 1989 were approximately 12 percent below 1980 levels.[24] The declining number of glass containers as well as increase in recovery of glass means that less glass enters the municipal solid waste stream. Because of limited data, it is difficult to identify the effect of this loss of market share on the amount of glass recycled.

The Mix of Glass Recycling Programs Available Affects Cullet Supply

Even though more states and localities are instituting recycling programs as a means of handling solid waste, effective and convenient glass recycling opportunities do not yet exist in all areas. One barrier that has slowed the establishment of glass recycling programs is the relatively low price of cullet. Still, when the avoided costs of landfilling are taken into account, recycling may be a less expensive method of handling glass (although the costs of both recycling and landfilling vary among communities) .25 If more communities become aware of the costs that can be avoided by recycling glass, the supply of cullet should increase.

Another factor affecting recycling rates is the type of collection. In some areas, the only recycling opportunities are provided by the beverage or container industry; these programs almost always require consumers to travel to a particular location (either a staffed center, an "igloo" disposal container, or a "reverse vending machine") to return their glass containers.

The most convenient option is collection of glass at the household. Curbside collection allows consumers to recycle glass with only the minimal effort of separating the glass from other trash (and sometimes sorting the glass by color). As a result, the supply of cullet is affected by the mix of curbside, drop-off, and deposit programs throughout the country. As more localities adopt curbside programs, the cullet supply should increase.

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[23]U.S. Department of Commerce, U.S. *Industrial Outlook 1990.*

[24]U.S. Department of Commerce, *U.S. Industrial Outlook 5–1990.*

[25]Although costs vary widely, disposal of a glass beverage bottle has an average cost of about 0.7 cents; this assumes two bottles per pound and the average tipping fee of $27 per ton reported in *Waste Age* in March 1989. With scrap prices over 1 cent per container ($50 per ton), this provides a difference of more than $75 per ton to offset the recycling costs. Recently promulgated federal regulations for municipal landfills will likely increase the avoided cost of disposal.

The Market for Cullet Is Regional

The variation in cullet price by region, discussed in Chapter II, shows that the market for cullet is regional, rather than national. Lack of a high volume of interregional scrap shipments allows cullet prices in different regions to differ greatly. The existence of large price differences by color in some regions and not in others also results from the regional nature of the market.

The transportation of cullet from the collection point to the glass plant is paid for by the supplier, not the end user of the cullet. (However, some manufacturers pay a $5-per-ton bonus for cullet shipped more than 50 miles, and an additional $5-per-ton bonus for cullet shipped more than 300 miles.) This means that the farther the cullet must be shipped, the less profitable it is for the recycler (a community, an intermediary who buys from the community, or individual consumers) to recycle glass. Furthermore, transportation is the largest cost component in supplying cullet. Consequently, little movement of cullet between regions occurs, allowing the price of cullet to differ greatly by region.

According to several state and local government officials interviewed, a significant amount of cullet crosses state boundaries. However, most interstate movement appears to occur between neighboring states, such as Iowa and Illinois, and may primarily reflect the color requirements of a certain plant. For example, a local plant may produce only clear glass and all colored glass would have to be shipped elsewhere, perhaps out-of-state. In the Northeast, cullet seems to move farther: both Maine and Connecticut officials report glass collected in those states moving as far as Pennsylvania. Even in the Northeast, however, no state or local officials reported significant interregional movements of cullet. In addition to the transportation cost, another factor inhibiting interregional movement may be that cullet collectors and processors are much more likely to be aware of the glass manufacturing plants in their own areas than in other regions of the country.

Recycling of Non-Container Glass Is Hampered by Handling Problems

Other glass products are much more difficult to recycle than containers, either because they are durable products or because they are mixed with other materials. For instance, light bulbs and other purchased glass products contain large quantities of metal. Flat glass maybe heavy and awkward for consumers to transport. Non–container glass does not account for a large share of municipal solid waste (although its share of industrial and commercial waste is unclear). The recycling of these products is hampered by physical constraints on collecting and handling; these constraints suggest that recycling these materials would be extremely expensive compared to the potential revenue.

Demand for Cullet

For the cullet market, the demand function expresses the relationship between a given price of cullet and the quantity that consumers of cullet will purchase at that price. The cullet market is typical in that some consumers are willing to buy some scrap at a relatively high price; however, if scrap suppliers wish to increase sales, they must lower the price of cullet to increase the quantity demanded.

The major factor determining demand growth over the next few years is likely to be the projected modest growth in glass container shipments, although there is still room for container companies to increase their percentage use of cullet. Glass container producers may be more likely to use cullet as they become convinced of the stability of cullet supply.

Alternative uses for cullet should show a small expansion as growing supply pushes down cullet prices. But those industries considering alternative uses may need some additional incentive to reconsider their current position on the feasibility of using cullet.

Factors Affecting Demand

The major factors we have identified are summarized below. The text that follows describes these issues in more detail.

- The container industry remains the major end user of post-consumer cullet.
- The major concerns of glass container makers in using cullet are contamination in the cullet and guaranteeing a reliable cullet Supply.
- The container industry is motivated to use available cullet because of benefits such as reduced energy use and because of concern over public image.
- Slow growth in the container industry means that industry's demand for cullet will grow, although modestly.
- Non-container glass industries face barriers to increasing cullet use; the barriers may be based on technical issues or on the cost of learning how to use cullet in their industries.
- An increasing supply of cullet should combine with sluggishly increasing demand, resulting in modest increases in cullet recycling.

Container Cullet Dominates the Cullet Market

Because of the short-term use of glass containers, as well as the manner in which recycling programs have been set up, container cullet has been collected more successfully from residential and commercial consumers than has any other type of cullet. And because it is easier for glass manufacturers to use cullet originating from only their own industries — cullet that generally already conforms to production requirements — most of the container cullet is purchased by the container industry for use in new containers.

Because of their few numbers and their dominance of recycling, the container companies effectively set cullet prices. The container companies are buying cullet at approximately $50 per ton, and other users of residential and commercial cullet must compete with the large container market for cullet. In many cases, cullet is not worth these prices to other cullet users such as fiberglass insulation or glasphalt manufacturers. Thus, although alternative uses for cullet are growing because of the general increase in cullet supply, alternative users still represent a very small portion of the post-consumer cullet market compared to the container producers. However, in some cases, where alternative users can purchase cullet in the area around their manufacturing plants, suppliers find it more profitable to sell cheaply to the nearby alternative user than to pay transportation costs to a higher–paying container plant farther away.

Consistency of Supply Is Critical to Glass Manufacturers .

Glass making is a continuous, closely–monitored process. The ingredients of glass — lime, soda ash, glass sand, and any cullet used in the process — are fed continuously into vats that operate 24 hours a day. The materials are melted in the vats, and the product is removed from the vats continuously. The mix of the inputs can be changed only slowly, and the transition glass produced during the changeover is unusable except as in–house cullet to be blended back into the process.

Because of the nature of the process, the ratio of cullet to virgin materials used can be changed only slowly during glassmaking. As a result, glass container manufacturers find that a major problem is guaranteeing a consistent supply of cullet. One strategy the container makers use to guarantee supply is to deal, when possible, with large intermediaries who can provide a greater volume of cullet with greater reliability than can small, individual communities or cullet processors.

The technical requirements of glassmaking also mean that short-run quantity demanded is probably not very sensitive to price. However, the major glass container manufacturers have maximum prices that they will pay for cullet, even in the short term, and there is no reason to believe that long–term demand for cullet would not be responsive to price. The combination of concerns

about a guaranteed supply, other nonprice influences on demand, and the historically stable price of cullet makes it impossible to predict how a substantial increase or decrease in cullet prices would affect the quantity demanded.

Container Companies Are Pushing to Increase Their Cullet Use

Like many other packaging manufacturers, glass container producers have been working hard to increase the recycling rates for their product, in part because recycling improves the industry's public image and also because increased recycling rates (i.e., increased cullet supply) will depress the price of cullet, thus decreasing production costs. In addition, because of the advantages mentioned in Chapter II associated with using cullet to replace virgin ingredients, the container industry has a long–term interest in seeing stable and efficient markets for cullet develop. Considering the competition among aluminum, glass, and plastic in the beverage container market, glass container makers need to be aggressive in finding ways to keep costs down.

How Glass Fares in the Competition with Aluminum and Plastic Will *Influence Cullet Demand*

Because cullet is an input to the glass container manufacturing process, a change in the volume of glass container production should affect the demand for cullet. (For example, if glass containers were to be replaced entirely by plastic containers, demand for cullet would obviously decrease.) Industry observers predict that the glass container industry will continue to see modest growth *over* the next few years. The U.S. Department of Commerce, for instance, projects that the volume of glass container shipments will rise approximately 1 percent during the 1990-1994 period.[26] This increase should slightly heighten the demand for cullet.

Color Is Important in Assessing Cullet Demand

Because of the technical specifications for the manufacture of glass containers, nearly all the cullet used in making glass of a particular color must be cullet of that same color. The Glass Packaging Institute estimates that roughly two-thirds of containers are made of flint glass, one–quarter are brown, and the remaining 8 or 9 percent are green. Flint glass, for instance, can contain no more than 5 percent amber cullet and no more than 1 percent green cullet. This means that the three major cullet colors are sold separately and that their market situations are not always the same.

For instance, in some areas with a heavy emphasis on recycling (areas like the Northeast with recycling mandates, deposit laws, and high disposal costs), the market is nearly saturated with green cullet because many imported beers are

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[26]U.S. Department of Commerce, *U.S. Industrial Outlook 1990.*

packaged in green glass. In these same areas, flint cullet is scarce and more expensive, while amber occupies a middle position. (See Table II–2.) The green glass marketing problems will be limited, however, by the relatively low share of green glass containers (8 or 9 percent) and the low share of imported glass containers — about 3 percent of all container types according to Department of Commerce estimates. So although markets for green cullet maybe fragile, the rest of the industry appears willing to handle more cullet.

Some Glass Industries Are Unwilling to Use Cullet

Another barrier to the expansion of alternative uses for cullet is an unwillingness to use cullet on the part of manufacturers in some glass industries. It is difficult to discern whether these industries — including many types of pressed and blown glass, flat glass, and fiberglass reinforcements — face technical barriers or whether the decision not to use cullet is an economic one. The answer is probably both. For example, the technical specifications for cullet for many of these glass industries are tighter (particularly for container cullet) than those of the container industry. But a similar reluctance to use cullet once prevailed in the container industry until the industry learned more about the nature of cullet and how to use it. Although many industry representatives said their companies could not use cullet, one company's technical expert indicated that, if prices or regulations changed enough to make it worthwhile, his firm would be compelled to find ways to use more cullet than it does today.

IV. Government Intervention in Cullet Markets

Government programs at the state and local levels are responsible for much of the glass recycling that occurs. Most of the post-consumer scrap is recovered from curbside, drop-off, or deposit programs mandated by or operated by governments. This chapter discusses the desirability of increased government involvement in glass recycling, describes existing policies, and then considers potential government involvement in the market with the objective of increasing recycling. The list of potential initiatives is not indicative of intended government actions or policies. Instead, it simply presents possible scenarios for consideration should a determination be made that the marketplace is not functioning properly and must be influenced to correct the problem.

Market-Based Incentives

In cases where significant environmental problems are caused by market failures, EPA strongly supports the use of economic incentives (at the appropriate jurisdictional level) to address the environmental problem rather than traditional command–and–control regulatory approaches. With the glass recycling markets, our conclusion to date is that incentive-based options are best applied at the state and local level, where the solution can be tailored to the particular needs of that jurisdiction.

Summary of Current Involvement

Government programs have affected the container sector of the glass industry through the introduction of deposit legislation and other recycling programs. Deposit laws were first enacted in the early 1970s and have focused primarily on beer and soft drink containers. Several states require deposits on other beverage containers, such as wine cooler, wine, liquor, and juice containers, but no states have deposits on non–beverage containers. Some states are considering advanced disposal fees on beverage and food containers.

The deposit programs increase the value of empty containers far above their actual scrap value. (Scrap value averages slightly more than a penny for a glass beer or soda bottle as described in Chapter III.) This higher value, combined with publicity about the program and numerous redemption locations, encourages returns. Under these programs, consumers return containers at retail outlets or redemption centers and redeem their deposits..

Mandatory recycling collection programs, which have emerged only in the last few years, are oriented less toward incentives and more toward command–

and-control than are deposit programs. These programs mandate the local development of recycling collection programs for many materials, often including glass. The most prevalent approach taken thus far requires consumers to separate glass from the waste stream at home, where it is subsequently collected by the community. These programs expand the types of glass accepted to include other container glass (e.g., food jars, liquor bottles, medicine bottles).

California's approach to container collection is different. The California program creates a redemption value of 2.5 cents on glass beverage containers. Consumers returning containers not only receive their 2.5 cents back but also may receive as a bonus a share of the funds generated by unreturned containers. The economic incentive makes the program similar to a deposit program, but the return is through an independent network of recyclers established and subsidized by the program. In addition, consumers may return any glass containers to these recycling centers, even if the container does not have a redemption value.

These three programs have similar effects on the supply side of the cullet market: they force more glass into the market than would otherwise be available. Voluntary recycling programs also facilitate the return of glass containers by making recycling opportunities more convenient. While precise estimates are not available, these government programs (i.e., deposit programs, mandatory recycling, and the California program) are responsible for a large majority of cullet used in the container industry.

Another form of government involvement in the cullet market is less obvious and almost certainly less significant. The federal tax code provides tax benefits (e.g., depletion allowances) for raw materials used in the production of glass and many other products. These benefits constitute a tax subsidy favoring the use of raw materials over cullet, since depletion allowances for natural gas and sand, for example, reduce the actual costs of those inputs. No analytical evidence exists that fully describes the effect of the subsidy.

Effects of Possible Federal Actions to Increase Glass Recycling

supply options

Mandatory container recycling at a national level would likely depress the price of cullet because the large increase in the supply of cullet following enactment of such a program would almost certainly lead to excess supply in the cullet markets. Furthermore, consumers would bear the cost of collecting and sorting the glass. Economic incentives designed to stimulate supply include tax credits on recycling equipment and operations, which also reduce the cost of supplying cullet, and deposit programs, which increase the value of empty containers and impose collection and handling costs on retailers and the beverage industry. Of course, the cost of these programs will ultimately be borne by taxpayers/consumers as well.

Another way to decrease the cost of supplying cullet is to encourage the establishment of larger, regional programs to collect and process material. Such programs would allow operators to achieve scale economies and to provide a higher-quality and more predictable supply for buyers. Programs in New Hampshire and in Montgomery County, Pennsylvania, are cooperatively marketing a range of recycled materials, including glass.

Finally, to increase the supply of recycled cullet, local government could discourage disposal of glass by ensuring that disposal fees cover the full costs of waste disposal and publicizing those costs. Awareness of full avoided disposal costs would increase the economic viability of collecting and recycling glass and other materials. Federal and state governments could also provide guidance to communities about how to compute their full avoided disposal costs. Since many communities are unaware of or underreport their disposal costs their customers, this would heighten awareness of recycling as a cost-saving measure. EPA is currently developing information to help communities assess and report the full cost ("true-cost accounting") of solid waste management.

Data on which forms of collection are the most efficient and effective are relatively scarce. The application of these incentives and programs would require additional information about costs, consumer behavior, and the demand side of the market.

Demand Options

Demand for scrap glass could be increased by offering incentives that make cullet a less expensive input, intervening directly in input markets, or improving the marketability of cullet. Incentives for cullet use include tax credits for cullet processing equipment (beneficiation units) or a tax credit for the glass producer based on the percentage or volume of cullet used in its batches. An alternative approach is to increase the cost of virgin glass by eliminating applicable depletion allowances or by assessing a tax on the production of glass with no recycled content.

One possible approach would be to require a minimum content of cullet in glass products. Unlike an incentive approach, this alternative does not take into account the various cullet market conditions faced by different producers and allows significantly less flexibility. Under this option, the government could either require that all glass procured by its agencies and contractors include a minimum recycled content or apply the requirement to all glass.

Another marketing option is to facilitate formation of regional marketing groups combining cullet from individual collection programs. One of producers' biggest risks in using cullet is that supplies will evaporate and they will not be able to sustain production with a given level of cullet input. Agents representing a large number of collection programs would have the ability to ensure a reliable flow of adequate quantities of materials.

Report Conclusions

Unfortunately, the data on glass recycling are inadequate to characterize the scrap market completely. The glass industry does not publish information on the uses of cullet, but available information indicates that the container industry is the primary end user of post-consumer cullet.

Post-consumer cullet is supplied through several different channels, including deposit-refund laws, curbside collection programs, drop-off centers, and buy–back centers. No data on the quantities of cullet supplied through each of these programs are systematically collected. It is estimated that approximately 73 percent of glass recycled in 1988 was beer and soft drink container glass. The remaining 27 percent was other container glass and non-container glass. This mix represents a change in the historical composition of cullet. Until recently, beer and soft drink containers accounted for virtually 100 percent of recycled glass. Growth in recycling programs, especially curbside programs, has increased the quantity of other glass recycled, resulting in the present mix. Continued growth in curbside and other recycling programs is likely given rising landfill costs, landfill capacity constraints, and resistance to siting new disposal facilities.

The increasing supply of post–consumer cullet is expected to coincide with moderately increasing demand for cullet, with the container industry continuing as the primary source of demand. The container industry is motivated to use available cullet because of benefits such as decreased energy use and the favorable public image it provides.

Markets for container cullet are regional, and are differentiated by color, with the green glass market the most fragile. The price of green cullet is less than that of amber or clear cullet because of the large quantity of green glass imported (e.g., foreign beers) and the more limited domestic uses of green cullet. Green glass accounts for a relatively small share of the total container market, however, and, while some regional markets might experience gluts of green cullet, green cullet markets are not saturated nationwide.

The overall outlook for glass recycling is healthy. Technical barriers to cullet use in the major market (containers) are few and consumers appear willing to return glass containers of all types given the opportunity. The rapid increase in the supply of containers from curbside and drop-off programs should offer reliable evidence to container manufacturers that supply will remain strong and that increased investments in cullet processing and use are warranted. The major concern that remains, however, is cullet quality. It is not enough that consumers are given the opportunity to return their bottles and jars: Consumers must be educated that color or ceramic contamination can render an entire trailerload of cullet worthless.

Other outlets for container cullet exist, but have not been price-competitive with container manufacturers in most cases. Of particular interest are lower–

value markets for contaminated loads or green glass cullet which is currently in excess supply in several parts of the country.

Other types of glass will continue to face substantial logistical problems with post-consumer recycling because of the disparate sources of relatively small quantities (e.g., window glass) and the difficulty of separating glass from other multi–material products (e.g., light bulbs). Nevertheless, with rising waste disposal costs and heightened consumer interest in recycling, even these sectors may see stronger incentives to recover glass and return it to manufacturers.

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