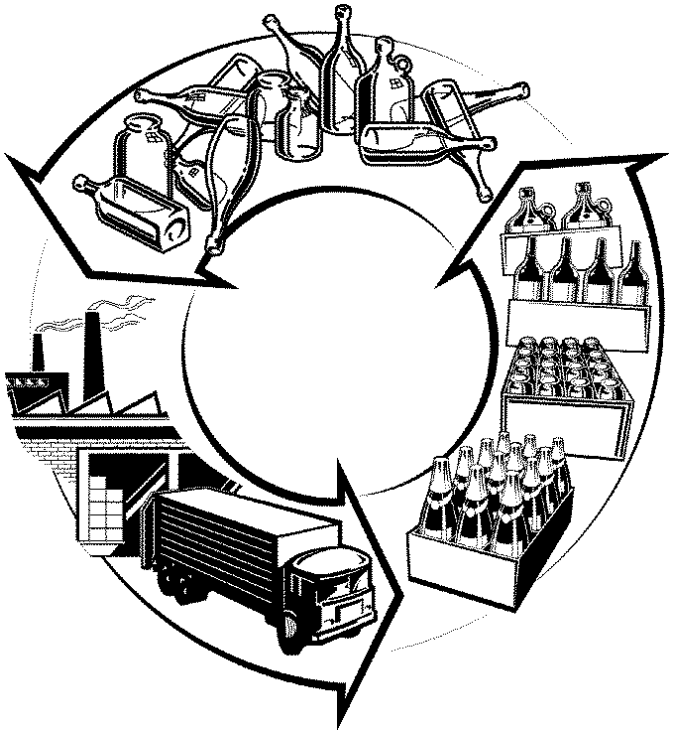
Glass

COMMODITY PROFILE

North Carolina Department of Environment and Natural Resources
DIVISION OF POLLUTION PREVENTION AND ENVIRONMENTAL ASSISTANCE

MARKETS ASSESSMENT 1998



OVERVIEW

During the past 15 years, the glass container industry has undergone significant downsizing and consolidation. Since the last market assessment conducted by the North Carolina Department of Environment and Natural Resources in 1994, the number of container manufacturing facilities has decreased from 71 plants in 27 states to approximately 60 plants in 25 states.[1] As would be expected, glass generation has shown a slight decline during this period as well. This decline is mainly because of an increase in the use of aluminum and plastics for food and beverage packaging.

In 1997, the 60 United States plants produced more than 36 billion individual containers, down from 40 billion in 1994.[2] These containers can be roughly characterized as 58 percent flint (clear), 33 percent amber (brown), and nine percent green.[3]

Containers and packaging glass can be characterized further as three basic types: beer and soft drink bottles, wine and liquor bottles, and food and other bottles and jars. Beer and soft drink bottles are easily the largest of the three categories, making up nearly 47 percent of all containers. Food and other bottles and jars make up about 35 percent, and wine and liquor bottles represent about 18 percent of container glass.[4]

Since the early 1980s, the production of glass containers has declined slowly. This decline generally is attributed to the increase in plastic and aluminum beverage containers and, more recently, the increase in plastic food containers. The downward trend in production appears to be ending. Production of glass containers is expected to remain steady or show a slight increase during the next few years.[5]

Figure 1. Estimated Generation (Tons) of Glass Containers in North Carolina, 1997 and 2002

Glass Type	1997	2002
Flint	141,099	148,154
Amber	67,727	71,114
Green	73,371	77,040
Total	282,197	296,307

This report estimates the generation and recovery of glass containers in North Carolina for 1997 and 2002 as well as the potential demand for recovered glass in North Carolina and surrounding states. Furthermore, this report attempts to clarify the relationship between the supply and demand for recycled glass containers and provide recommendations for improving this relationship in North Carolina.

GLASS CONTAINER AND PACKAGING SUPPLY

Generation

Generation and recovery of container glass from public and private sources in North Carolina were calculated for 1997 and 2002 using published data, private industry surveys, and local government recovery data. Because national data is provided as overall glass packaging, without regard for color, national estimates were separated into color categories using national production characterization data with adjustments made for imports. A flint:amber:green generation ratio of 50:24:26 was chosen based on various sources and the 1994 market assessment. The actual 1997 recovery ratio in the state was 47:30:22.[6]

Estimates for glass generation in North Carolina for 1997 were developed using data published by the Glass Packaging Institute (GPI) and the U.S. EPA. The GPI data were averaged with projections based on EPA data and extrapolated for North Carolina based on the 1997 population. Projections for 2002 then were made based on an EPA estimated five-percent increase in glass production during a similar period and a six-percent increase in population as estimated by the North Carolina Office of State Planning.[7] The ultimate result is a one-percent decrease in per capita glass generation by 2002. Generation data for North Carolina provided in Figure 1 are based on the previously mentioned five-percent increase in production.

Recovery

The majority of glass recovered in North Carolina is from local government collection programs. Although substantial quantities of glass may be generated from restaurants, bars, hotels, and the like, recovery from these facilities is minimal. Some commercial sources of glass containers may be included in local government tonnages. However, tonnage recovered from non-residential sources is assumed to be less than 10 percent of all glass recovered in the state.

Even with local governments supplying more than 90 percent of the state's recovered glass, there are many local governments in North Carolina that do not provide glass recycling, and those that do recover only a small portion of the quantity generated. Some of the state's most successful recycling programs are recovering only about 20 percent of their glass. There are several reasons for low glass recovery including a lack of public education activities, processing costs, and transportation costs. These reasons are discussed later in this report.

Many circumstances likely affecting the supply of glass from local government sources apply to commercial sources as well. The main difference is that profits or cost avoidance become a more critical factor. To see a substantial increase in glass from commercial sources, the state most likely would need to experience an increase in the price paid for unprocessed glass or a substantial increase in tipping fees at disposal facilities.

Estimates of glass recovery were developed using annual local government solid waste management reports and a survey of private recyclers conducted by the North Carolina Recycling Business Assistance Center. With exception of fiscal year 1997, the general trend in local government glass recovery during the past decade is upward. Local government glass recovery data for fiscal years 1990-91 through 1996-97 are provided in Figure 2.

Local governments reported a significant tonnage of mixed glass on state annual report questionnaires in fiscal year 1996-97. These data most likely are reported to local government by private haulers as mixed glass, although in reality the glass is separated at a processor or drop-off facility. A recovery ratio of 47:30:22 (flint:amber:green) was applied

Figure 2. Local Government Glass Recovery (Tons) in North Carolina, 1990-91 to 1996-97

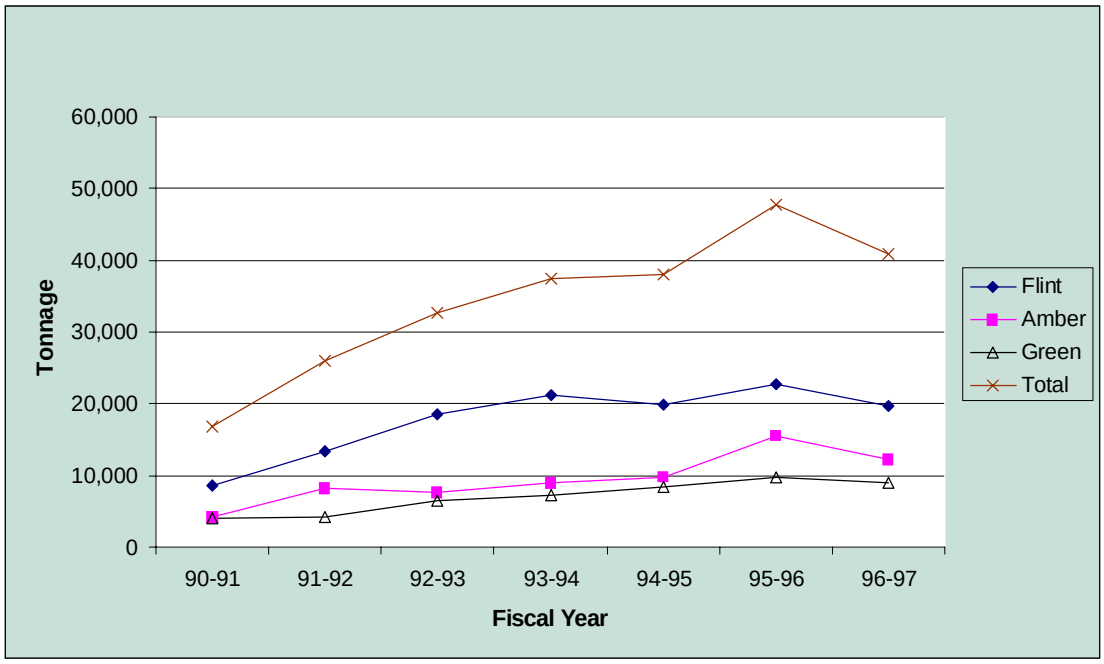


Figure 3. Estimated Recovery of Glass Containers in North Carolina 1997 and 2002

Glass Type	1997		2002	
	Tons	Percent	Tons	Percent
Flint	23,134	16.396%	24,542	16.565%
Amber	11,499	16.978%	12,231	17.199%
Green	10,392	14.164%	11,048	14.34%
Total	45,025	15.956%	47,821	16.139%

to the aggregate mixed glass tonnage to develop an overall color sorted tonnage for the state.

Reports submitted by local governments in the state indicate a drop of about 7,000 tons in recovered tonnage from fiscal year 1995-96 to fiscal year 1996-97. Two possible contributing factors to this decrease are:

- In 1994 and 1995, high market prices for several recyclable commodities resulted in increased efforts towards recycling. These prices returned to normal levels, as did the added boost to recycling programs.
- Annual reporting in fiscal year 1996-97 saw a 250 percent increase in tonnages reported as commingled. These commingled tonnages likely contain significant amounts of glass that are not quantifiable.

The second factor alone could underestimate glass recovery by several thousand tons. Overall, the decrease in tonnage in 1996-97 is not a concern yet. Nationally, both glass production and glass recovery saw declines during this period, and on a state level, many other commodities commonly collected by local governments also declined.

Unfortunately, data is not available to compare changes in commercial recovery from 1995-96 to 1996-97. Data were available, however, from research conducted by the Division of Pollution Prevention and Environmental Assistance in 1995. A comparison of these data indicates commercial glass recovered increased more than 100 percent from 1994-95 to 1996-97, but still represents less than 10 percent of total recovery.

The 1997 national recycling rate for glass containers was approximately 31 percent.[8] The State of North Carolina, as indicated in Figure 3, is only recovering about 45,000 tons, or 16 percent of the generation estimate, which is well below the national average. Without significant efforts from both commercial sources and local governments, the per capita recovery probably will remain about the same for 2002, which will represent an increase in tonnage to about 48,000 tons but no change in the total percent recovered.

Figure 4. Estimated Generation and Recovery of Glass Containers in North Carolina 1997 and 2002

Glass Type	1997		2002	
	Generation	Recovery	Generation	Recovery
Flint	141,099	23,134	148,154	24,542
Amber	67,727	11,499	71,114	12,231
Green	73,371	10,392	77,040	11,048
Total	282,197	45,025	296,307	47,821

As can be seen from Figure 4, the potential exists to significantly increase glass recovery tonnages. A doubling of current recovery would yield a rate similar to national average recovery. Furthermore, conversations with glass beneficiators indicate that processing capacity is available to handle such an increase in recovery.

GLASS CONTAINER AND PACKAGING DEMAND

Overview

In 1994, there were eight glass container manufacturing plants in North Carolina and its surrounding states. With the closure of the Ball-Foster Plant in Laurens, South Carolina, there are currently only seven container manufacturing plants. Three of these manufacturing plants are in North Carolina, and there are two facilities in both Georgia and Virginia. Further information regarding these facilities is discussed later in this report.

End-use markets for glass containers generally can be classified as two types: primary ¾ end-users that turn glass containers back into glass containers; and secondary ¾ end-users that use glass for purposes other than making glass containers. From a processing standpoint, this terminology can be somewhat misleading. That is, secondary markets do not necessarily require less processing. In some cases, particularly with fiberglass insulation, a higher level of processing may be required than for a primary market.[9]

The glass container industry is by far the largest end-user of glass cullet (broken/crushed glass) in the United States. Regardless of strict industry specifications for recycled cullet, almost 80 percent of all glass designated for recycling in 1997 was made back into glass containers.[10] Based on the sporadic nature of secondary markets, the glass container industry will remain the dominant end-user of glass cullet. This report focuses on primary markets, however, secondary markets identified during this assessment will be reviewed.

Several characteristics relating to the melting point of container glass cullet make it advantageous for glass container manufacturers to use.

- Cullet melts at a lower temperature than virgin batch. With the appropriate amount of cullet, furnaces can run at temperatures as high as 200 F lower than if all virgin batch is used.[11]
- Therefore, the use of cullet requires less energy than 100 percent raw materials. On average, for every 10 percent cullet used, the manufacturer will save 2.5 percent in energy costs.[12]
- Beyond saving energy costs, running lower furnace temperatures also can extend the overall furnace life.
- Container glass is 100 percent recyclable and shares the same characteristics of other container glass. For example, one ton of cullet from beer bottles can yield a ton of jars, cosmetic bottles, etc.

Given the potential energy cost savings provided by the use of cullet in making new container glass, purchases of cullet usually are given a small price preference over virgin materials. Conversations with several glass manufacturers indicate this preference is somewhere in the range of five percent.

In the early 1990s, the main concern surrounding glass recycling was an oversupply of green cullet. Although locating end users for green cullet still remains an issue throughout North Carolina and the United States, contamination currently is the major concern surrounding glass recycling.

The Institute of Scrap Recycling Industries (ISRI) sets specifications for processed and unprocessed glass cullet nationwide.[13] These specifications identify the following as prohibitive materials or contaminants: ferrous and non-ferrous metals, ceramics, other glass (plate glass, heat resistant glass, lead based glass, television glass, vision ware, etc.) and other materials (bricks, rocks, etc.). Conversations with various manufacturers indicated ceramics as a major concern in the southeast, although aluminum caps also were indicated as a problem material. Specifications for processed cullet are strictest for flint cullet, which must have less than five percent non-flint cullet. Amber follows with as much as 10 percent non-amber cullet allowable in the mix, and green can withstand up to 30 percent non-green cullet and still be useable.

Figure 5. Estimated Production of Glass (Tons) in North Carolina and Surrounding States, 1997

State	Flint Glass	Amber Glass	Green Glass
North Carolina	203,695	64,324	0
Georgia	66,707	171,533	0
Virginia	59,560	50,626	0
Total	329,962	286,483	0

Local government recycling programs have grown substantially in North Carolina since the late 1980s. With this growth has come an increase in the need to process more materials and a switch from curb/generator-sorted recycling to commingled recycling. Source separated glass at drop-off centers is still common. While the increase in glass collected has helped the state with efforts to reach its 40 percent waste reduction goal, it also has raised concerns for the glass manufacturing industry.

While the quantity of cullet supplied to glass manufacturers has increased, the quality has decreased, creating problems for manufacturers, and in some cases resulting in loads being rejected. All seven glass manufacturers in North Carolina and surrounding states indicated that the quality of the glass being supplied was a key concern, and two facilities either stopped taking municipally collected glass or altered the method by which they obtain their cullet.

Improperly cleaned transport vehicles are another source of contamination. Improper rinsing or sweeping of a vehicle that had previously transported a load of stone or similar materials could result in the contamination of a processed load of cullet.

These concerns about contamination have expanded the use of intermediate processors or benificiators. There are two such processors in North Carolina and two in Georgia that handle significant quantities of glass. The purpose of these operations is to improve the quality of color sorted, mixed whole/broken glass to furnace-ready quality. North Carolina facilities are the Container Recycling Alliance (CRA), located in Raleigh, and Owens-Brockway processing facility, located near Winston-Salem. Because of limited locations, long travel distances often become a concern for glass suppliers such as commercial establishments and local governments.

Production

Demand for glass in North Carolina and its border states was difficult to ascertain. The glass container industry is very competitive and keeps production, capacity, and other proprietary figures well guarded. It was, therefore, necessary to develop an alternative method to estimate production and demand for the industry. Production based on employment was chosen as the best substitute.

National employment figures were compared to national glass production estimates to generate average production per employee. This national production per employee factor was then applied to employment figures for the seven regional manufacturers to determine glass production per facility. These figures were further adjusted to represent the colors produced for each facility. Anecdotal information obtained during this assessment indicates that technology differences between facilities may result in significant over or under estimation of glass production. This same information indicates that North Carolina production calculations may greatly underestimate actual production. On a regional level however, production estimates should more closely reflect actual production. Production levels are given on a state and regional level only. These figures are presented in Figure 5.

There are seven glass manufacturing plants in North Carolina and surrounding states. Location, employment, and production background are provided in Figure 6.[14] All seven facilities use recycled cullet in the production of new flint and amber glass. Unfortunately, neither Virginia facility receives cullet from North Carolina sources. No green glass is produced in North Carolina or surrounding states.

Demand For Flint And Amber Cullet

The potential demand or overall capacity to handle glass cullet has increased through the years. The use of cullet in furnaces has grown substantially since the early 1980s. Today glass manufacturers nationally are using about 35 percent cullet, including cullet produced in-house from breakage and defects.[15] If only post-consumer cullet is considered, the average bottle is in the range of 27 percent recycled content, which appears representative of production in the southeast.[16]

It has been shown that glass manufacturers can sustain glass cullet percentages in the range of 70 to 75 for green and amber and up to 55 for flint.[17] Although these levels are

Figure 6. Glass Container Manufacturers in North Carolina and Surrounding States, 1997

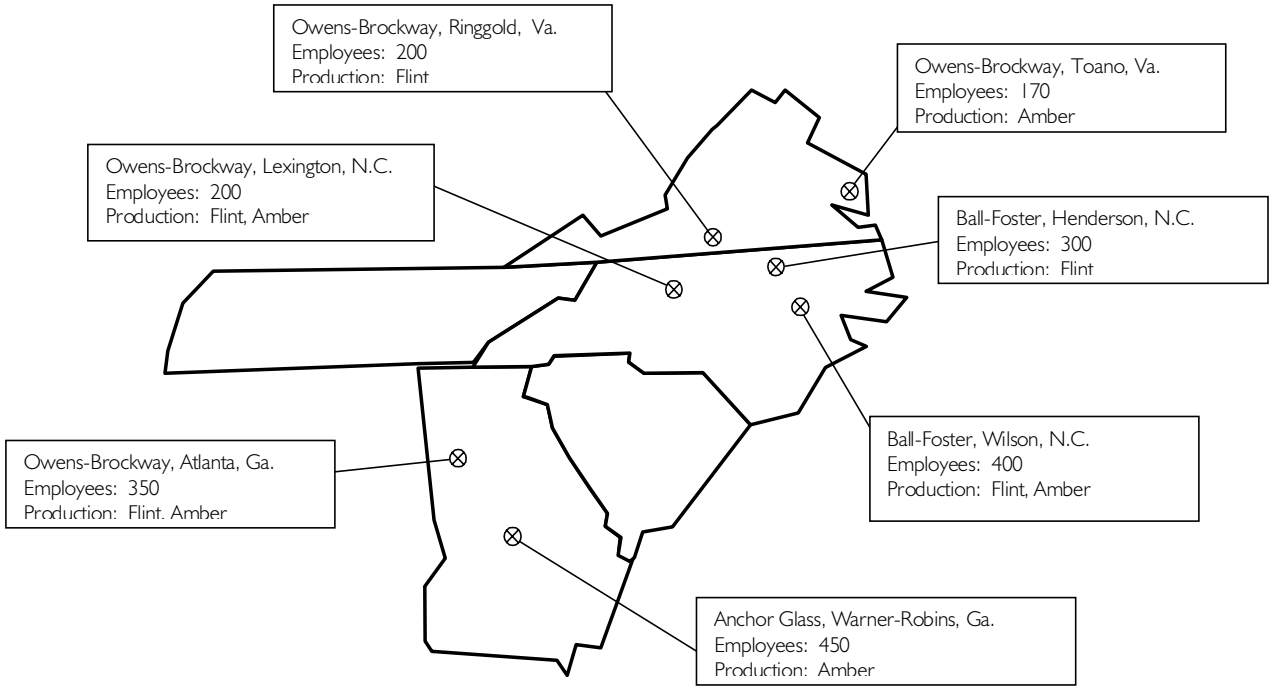


Figure 7. Potential Estimated Demand for Glass Container Cullet in North Carolina and Surrounding States

	1997	**2002**
North Carolina		
Flint	112,033	117,635
Amber	45,027	47,278
Green	10,392	11,048
Total	**167,452**	**175,961**
North Carolina and Surrounding States		
Flint	181,480	190,544
Amber	200,540	210,567
Green	10,392	11,048
Total	**392,412**	**412,159**

sustainable, the cullet supply must be consistent and very well processed. In one extreme instance in Pennsylvania, a severe winter resulted in a low supply of soda ash. To compensate for the lack of soda ash, an Anchor facility in Royersford, Pennsylvania, used 100 percent recycled cullet for seven weeks, generating 100 percent recycled green bottles.[18]

To determine the potential demand for glass from primary markets in North Carolina and surrounding states, the optimal in-furnace percentages were used. Cullet:virgin ratios of 55:45 and 70:30 were used for flint and amber respectively. For example, to determine the potential demand of flint cullet for a specific facility, the facility's estimated flint production was multiplied by 0.55. Projected demand for 2002 was also developed based on an EPA estimate of five percent increase in production with all other assumptions held constant.[19] Demand estimates for 1997 and 2002 are provided for North Carolina and North Carolina and surrounding states in Figure 7. It also must be noted that two of these facilities are not currently receiving glass from North Carolina, and some or all of these facilities accept glass from sources other than North Carolina. No attempt was made to adjust for these factors. Estimated supply and potential demand for flint, amber, and green cullet in 1997 and 2002 are provided in Figure 8, and their relationship is discussed in the following section.

Figure 8. Supply and Potential Demand for North Carolina and Surrounding States, 1997 and 2002

North Carolina	Flint		Amber		Green		Total	
	1997	2002	1997	2002	1997	2002	1997	2002
Supply	23,134	24,542	11,499	12,231	10,392	11,048	45,026	47,821
Potential Demand	112,033	117,635	45,027	47,258	10,392	11,048	167,452	175,961
North Carolina and Surrounding States	**Flint**		**Amber**		**Green**		**Total**	
	1997	**2002**	**1997**	**2002**	**1997**	**2002**	**1997**	**2002**
Supply (N.C. Only)	23,134	24,542	11,499	12,231	10,392	11,048	45,026	47,821
Potential Demand	181,480	190,544	200,540	210,567	10,392	11,048	392,412	412,154

Demand for Green Cullet

Although no green glass is being produced in North Carolina or surrounding states, green glass is accepted for processing. Processors are accepting green glass and in some cases shipping it to facilities several states away. Some green glass also is being mixed with amber cullet for the production of amber glass. One southeastern glass manufacturer indicated using a 60:40 (amber:green) mix of cullet for the production of amber glass. This likely represents a significant quantity of green glass recovered in the state. Although processors are willing to accept green glass, it is unlikely that any processors or end-users in the region are actively seeking it. Demand for green glass was, therefore, assumed to be equal to supply for 1997 and 2002.

The only national figures available for green cullet demand indicate that imports of green glass likely create a supply over green production of about one million tons annually.[20] These figures, however, are dated and may no longer represent the industry. National production figures from various sources indicate a decrease in the established nine percent green glass production figure as a percentage of United States production. On the other hand, increases in the percent of cullet used, the ability to utilize some green cullet in the production of amber glass, exports of green cullet to other countries and an increase in secondary markets may have off-set this decrease in production. Nevertheless, the supply of green glass in the U.S. likely exceeds demand.

Demand From Secondary Markets

Attempts to quantify the amount of glass going into secondary markets were not successful; however, anecdotal information obtained during this assessment indicates that quantities are small. Demand by secondary markets is, therefore, assumed to be zero. Although demand is considered to be virtually zero, several small markets do exist, and others are in development. Examples include:

- Potters, Inc., located in Apex, North Carolina, uses flint cullet as glass beads for the production of reflective road markers. Potters, Inc., requires cullet to be processed and clean of contaminants.
- The North Carolina Department of Transportation recently investigated the use of glass cullet as an aggregate for construction.
- A materials recovery facility (MRF) in Mecklenburg County has developed a market in Tennessee. Glass that does not meet the quality specifications of glass container manufacturers is finely ground and sent to Tennessee where it is mixed with soil and utilized for landscaping purposes.
- A Georgia glass processor markets glass that does not meet specifications to a copper melting facility that uses the glass as a fluxing agent.

Although secondary markets do not account for significant glass capacity in North Carolina and surrounding states, they are still an important aspect of glass recycling. This is especially true for secondary markets that accept mixed color glass or off-spec glass that would normally be landfilled. Although secondary markets have grown and are expected to continue growing, it is difficult to determine their current and future impact. One estimate indicates more than 70 non-container uses for glass including asphalt (glassphalt), aggregate, glass bead, filter medium, and insulation products. However, many secondary markets are still in the research phase and, in many cases, end-products need state-by-state approval such as the use of glassphalt.[21]

SUPPLY / DEMAND RELATIONSHIP

Because the majority of demand for cullet is from primary markets, this assessment of the supply / demand relationship will focus on primary markets. It is apparent that the supply of processed flint and amber cullet in North Carolina and the southeast is well below the potential demand. Without significant efforts to increase the supply of pro-

cessed flint and amber glass, this trend undoubtedly will continue until 2002 and beyond. On the other hand, demand for green cullet is approximately equal to supply and most likely will not deviate from this pattern through 2002. It appears overall that the focus of the glass industry is on the quality of the current supply rather than increasing supply.

All but one of the glass manufacturers contacted during this assessment indicated their facilities could handle a doubling of the amount of cullet currently in use. In most cases end-users indicated they would like to increase cullet supply. In fact, one manufacturer indicated that he would like to quadruple his current cullet intake. Unfortunately, the recovery of glass generated in North Carolina is only 16 percent, about half that of national recovery and well below end-use capacity.

Up to this point, the supply of cullet has been compared to the potential demand if end-use facilities use optimal amounts of cullet. In a sense, this is a theoretical relationship between what is supplied from generators and what could technically be utilized by end-users. The actual relationship between generator and end-user is much more complicated.

The advent of glass beneficiators has created two distinct supply/demand relationships for glass recycling. The first relationship is between the glass generator (local governments, commercial establishments, etc.) and the beneficiator. Conversations with beneficiators in North Carolina and surrounding states indicate supply at this level may be as much as 50 percent below demand, or processing capacity. Given end market constraints, it can be expected that actual demand is somewhat near, if not at capacity. Although an increase in market prices paid by beneficiators might increase the supply, it is unlikely this will occur without a parallel increase in prices paid by end-users.

The second relationship occurs between the beneficiator and the end-user. Once again, as can be seen throughout this report, end-use supply is low compared to the potential demand. Other factors such as the availability of virgin materials play a part in this relationship. As long as raw materials are available, the glass industry is much more likely to focus efforts on increasing quality. In fact, the industry views the increase in supply as the ultimate cause of decreased quality.

To better understand how prices for furnace-ready cullet are determined, both beneficiators and end-users were contacted. From the beneficiators standpoint, the cost of processing plays a large part in what price will be accepted, and from the end-users standpoint, it appears the cost of virgin materials plays a role.

Factors Affecting Recovery/Supply

Many factors beyond supply/demand economics affect supply and demand. This is true particularly for the supply of glass. Local governments are the largest supplier of glass statewide. As mentioned earlier, many North Carolina local governments do not provide glass recycling, and those that do, are recovering only a small portion. There are three key reasons why more glass recycling is not taking place on the local government level. The first and most important is public education. Public education is a critical component of all recycling programs. However, since the early 1990s, when recycling programs were first implemented, public education has likely dropped significantly. An increase in targeted public education programs statewide would likely increase the quantity of glass collected as well as the quality.

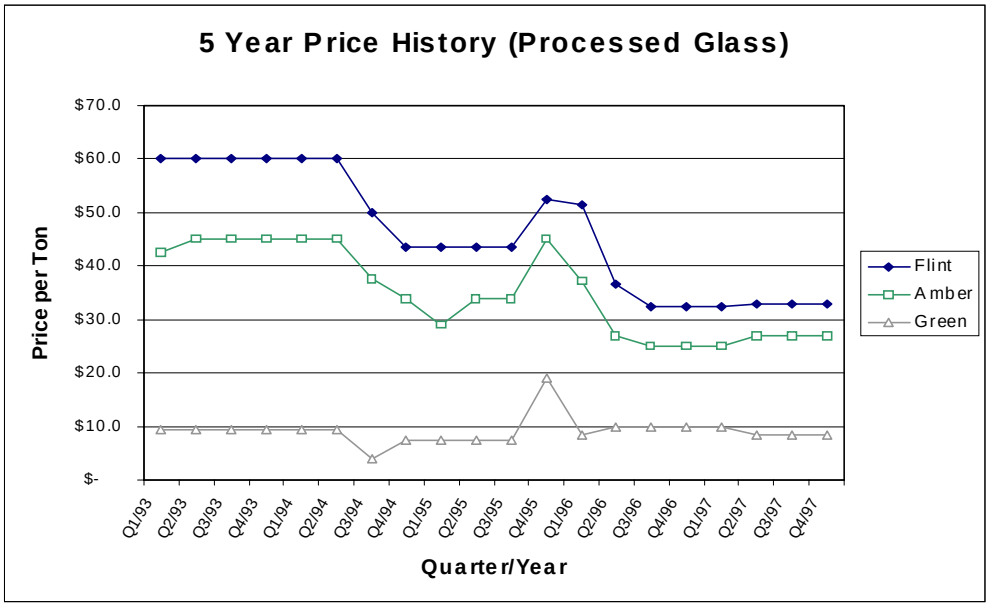
A critical factor in the supply of glass cullet is processing. Glass must meet strict standards to be considered furnace ready, and meeting these standards is expensive. The increased costs of processing glass often results in a low price paid for glass by the processor, making it less profitable for generators.

Transportation is another factor closely related to processing. Because there are only two glass processors in the state, once glass is collected, it must be transported long distances for processing, adding additional costs to recycling. Unfortunately, because of the bulkiness of glass, a generator would need significant storage space to maximize the efficiency of transporting loads to a beneficiator. Because most generators do not have this space available, inefficient transport of glass is a common occurrence, further increasing the cost of glass recycling.

To combat this problem in eastern North Carolina, the Eastern Carolina Vocational Center (Greenville, North Carolina) installed glass bunkers, which are basically large storage bins for glass. This setup allows glass recyclers in the eastern part of the state to haul their color sorted glass to Greenville, North Carolina. Although paid less for their glass at the Greenville facility than at a beneficiator, the avoided transportation costs likely out-weigh the decrease in revenue.

In a similar case, New Hanover County installed glass bunkers to allow more efficient hauling to the Raleigh processing facility. The efficiency achieved from this system resulted

Figure 9. Five Year Price History for Processed Glass in the Southeast (End-user Prices)



in a revenue of $10.87 per ton rather than a previous cost of $38.19 per ton. No such facilities exist in the western part of the state.

Price History

Processed glass prices traditionally are among the most stable of all recycling commodities. Prices for flint and amber glass experienced some downward movement from 1993 to 1995, but overall have been relatively constant since 1996. Prices are expected to remain about the same in the future with changes likely approximating those in the cost of virgin materials. Figure 9 provides a five-year price history for glass cullet in the southeast.

CONCLUSION

Glass recycling has advanced substantially since the late 1980s. Likewise, the use of glass in furnaces also has increased. In the early 1990s, the main concern surrounding glass recycling was an oversupply of green cullet. Although locating end users for green cullet still remains an issue throughout North Carolina and the United States, currently, contamination is the major concern with glass recycling and most likely will remain the key issue for some time.

It is likely that contamination concerns have increased as municipal recycling programs have expanded. Unfortunately, contamination has become such an issue that one manufacturer indicated it no longer purchased cullet from processors, and another indicated it will not accept municipal cullet.

This increase in contamination is the result of two main factors.

- The first is the difficulty in educating the public, or, in some cases, the lack of local government education programs. The public consistently mixes contaminants with glass believing they are recyclable. The most common contaminants are ceramics, caps, and heat-resistant glass such as vision ware.
- The second factor is that an increase in commingled collection of recyclables has made processing more difficult. Technologies such as ceramic detectors and optic sorters currently are available to enhance processing capabilities. However, they are expensive and require large volumes of glass to justify investments. One processor in North Carolina currently is investigating its installation.

Although demand issues can be overcome, it will be difficult to substantially increase the amount of glass supplied to processors, especially from commercial sources. The recycling of glass does not guarantee a profit or even cost avoidance – key issues for increasing the glass supply from commercial sources. The challenges of transporting glass efficiently and the high cost of processing glass ultimately will control the supply of glass.

RECOMMENDATIONS

It is likely that without significant change, the potential and actual demand for recycled glass will remain higher than

the supply. Some steps that could be taken to improve the quality of glass cullet supply and reduce the gap between supply and demand are:

- Local governments should be encouraged to institute or expand public outreach and education programs. Such efforts, if properly focused, should result in an increase in quantity and quality of all recyclable materials.
- Glass bunkers should be utilized where possible to increase the efficiency of transporting glass, particularly in the western part of the state.
- To increase the quantity of glass collected throughout the state, equitable, waste reduction based collection systems such as pay-as-you-throw (PAYT) should be encouraged. PAYT programs charge system users based on the amount of waste generated, thereby providing financial incentives to reduce and recycle.
- Local governments should be encouraged to implement glass recycling programs where programs do not already exist and seek methods for improving the efficiency of existing programs. An example of a possible method for improving efficiency is local government partnerships for hauling and marketing.
- To increase commercial glass recycling, public/private partnerships should be encouraged throughout the state. Such partnerships would allow commercial generators to begin recycling glass without significant additional costs. These partnerships also should create new efficiencies in local government programs.
- Glass manufacturers should be encouraged to increase their involvement with local governments to further explain contamination issues and how to improve the quality of glass supply.
- Glass beneficiators should be encouraged to work with local governments to increase the quantity and quality of glass supplied. Beneficiators should also be encouraged to investigate new technologies for glass processing.
- The Division of Pollution Prevention and Environmental Assistance (DPPEA) should continue to identify secondary markets for glass and expand the *Directory of Markets for Recyclable Materials* to include markets for mixed cullet.
- DPPEA should continue to assist local governments and businesses in expanding and improving recycling programs.
- The N.C. Department of Transportation should take the lead role in investigating the use of recycled glass as an aggregate and for other products such as glassphalt.

[1] Personal communication with Dave Baker, Area Director, Southeast Region, Glass Packaging Institute, June 1998.
[2] U.S. Department of Commerce, "Glass Containers - 1997 Summary (M32G[97])," *Current Industrial Reports*, U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census, June 1998.
[3] Personal communication with Dave Baker, Area Director, Southeast Region, Glass Packaging Institute, June 1998.
[4] U.S. EPA, *Characterization of MSW in the United States: 1997 Update*, June, 1998.
[5] Tyler, Nathan. "Glass Recycling: Cause and Effect," *Resource Recycling*, Vol. XV, No. 8 (Aug 1996), pp 39-42.
[6] Total may not equal 100 due to rounding.
[7] U.S. EPA, *Characterization of MSW in the United States: 1996 Update*, June, 1997.
[8] The Glass Packaging Institute estimates 1997 recovery for glass containers as 35 percent nationwide. For the purposes of this report, refillable containers were removed from GPI's data resulting in a recovery rate of 31 percent.
[9] Personal Communication with Bob Sinclair, GDS, Inc., June 1998.
[10] Glass Packaging Institute, *Americans Continue to Recycle More Than One in Three Glass Containers* (Press Release), April, 1998. Figures were adjusted to exclude refillable bottles.
[11] "Recycling Markets Profile: Glass Containers," Supplement, *Resource Recycling*, 1994.
[12] Glass Packaging Institute, *Glass Recycling Source Book*, 1st Ed., 1996.
[13] Institute of Scrap Recycling Industries, Inc., *Scrap Specifications Circular 1998*, 1998.
[14] Data provided from a DPPEA industry survey, June 1998.
[15] Personal Communication, Dave Baker, Area Director, Southeast Region, Glass Packaging Institute, June 1998
[16] Miller, Chaz, "Profiles in Garbage: Glass," *Wasteage*, Vol. 28, No. 10 (Sep. 97).
[17] Personal Communication, Dave Baker, Area Director, Southeast Region, Glass Packaging Institute, June 1998
[18] "Recycling Markets Profile: Glass Containers," Supplement, *Resource Recycling*, 1994.
[19] U.S. EPA, *Characterization of Municipal Solid Waste in the United States: 1996 Update*, June 1997.
[20] Apothecker, Steve, "Glass Containers: How Recyclable will they be in the 1990s," *Resource Recycling*, Vol. X, No. 6 (Jun 1991), pp 25-32.
[21] "Recycling Market Profile: Glass Containers," Supplement, *Resource Recycling*, 1994.