

Plastic: HDPE (#2)

COMMODITY PROFILE

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

MARKETS ASSESSMENT 1998



OVERVIEW

High density polyethylene (HDPE) is one of a class of plastic resins obtained by polymerizing the gas ethylene. Low density polyethylene (LDPE) and linear low density polyethylene (LLDPE) are discussed in a separate commodity profile. The most familiar consumer item that is made from HDPE is the milk jug. Other common containers made from HDPE are shampoo and other detergent bottles where pigments often are mixed with the polymer. Recently, some dairies have begun using colored HDPE milk jugs as well.

Much of the current recovery of HDPE is through municipal curbside and drop-off collection programs. Many of these programs usually focus on the "natural" form of HDPE, which is translucent, and do not collect colored bottles. There is room for more collection of HDPE and efficiency can be increased through the collection of all plastic bottles and use of plastic compaction on collection vehicles. HDPE prices dipped in 1996, but have not been affected as greatly as PET by burgeoning virgin supply.

SUPPLY

Current Generation

The Environmental Protection Agency (EPA) has estimated the generation of discarded HDPE in the United States. Figure 1 presents generation estimates per product category, along with extrapolated estimates for North Carolina's share of national generation. North Carolina estimates are based on percent of United States population (2.78 percent), and these estimates are rounded to the nearest 100 tons. Because significant differences in generation exist from state to state, the North Carolina estimates should only be considered rough estimates.

The American Plastics Council (APC) generation figures for 1996 are approximately 36 percent higher than EPA's figures. Part of the difference could come from how each organization estimates generation. APC figures come from plastic resins produced, whereas EPA attempts to estimate the amount of materials disposed or recycled at the end of their useful life.

Figure 1. HDPE Generation, 1996 estimates (tons)

Product Category	Estimated United States Generation	Estimated North Carolina Share
Durable Goods	450,000	12,500
Trash Bags	230,000	6,400
All other non-durables*	350,000	9,700
Soft drink bottle base cups	20,000	600
Milk and water bottles	650,000	18,100
Other plastics containers	670,000	18,600
Bags, sacks, and wraps	520,000	14,500
Other plastics packaging**	1,230,000	34,200
Total Generated HDPE	4,120,000	114,600

* Includes plastics in disposable diapers, clothing, footwear, etc.

** Other plastic packaging includes coatings, closures, caps, trays, shapes, etc.

Source: US EPA, *Characterization of Municipal Solid Waste in the United States: 1997 Update*

The most commonly recovered form of HDPE is blow-molded bottles. In addition, some film extruded HDPE grocery bags are recovered. These two items fall under the categories of “soft drink bottle base cups,” “milk and water bottles,” and “bags, sacks and wraps” in the EPA data and total 33,200 tons generated in North Carolina in 1996. The readily recoverable portion based on EPA’s categories are shaded in Figure 1 (“soft drink bottle base caps,” “milk and water bottles,” “other plastic containers,” and “bags, sacks, and wraps”) and totaled 51,800 tons in North Carolina in 1996.

Another method of estimating generation of plastic waste is the use of the resin in consumable goods. Figure 2 presents the use of HDPE in various items in 1996. The categories presented in this Society of the Plastics Industry (SPI) data that can be determined as readily recovered are shaded and include “food packaging,” “industrial and shipping pails,” “food tubs/containers and drink cups,” “liquid food bottles,” and “household chemical bottles.” The total of these categories is 48,800 tons in North Carolina in 1996. This number is slightly lower than the estimate using EPA’s data, because the film category identified a more specific and smaller fraction of the total film produced to be recoverable.

HDPE is made into products using five major manufacturing methods: blow-molding, injection molding, blown film/cast film, profile extrusion (pipe and conduit), and rotomolding. These methods are described below and Figure 2 presents their impact on manufacturing in 1996.

- Thirty-five percent (1,460,500 tons) of HDPE used in 1996 was blow-molded into bottles, drums and other containers. Blow molding uses compressed air to conform a molten tube of plastic to the inner layer of a cooled mold. SPI figures show 1996

HDPE demand for liquid food bottles to be 641,000, or nine percent of all HDPE consumed in 1996. Household chemical bottles consumed another 497,500, or eight percent of all HDPE.

- Manufacturers used 19 percent (1,056,000 tons) of HDPE to injection mold a variety of items including industrial and shipping pails, housewares, crates and totes, toys, novelties, sporting goods, caps and closures, food tubs/containers, and drink cups. In injection molding, plastic is heated into the liquid state and then injected into a cool mold. In 1996, injection molded food tubs/containers and drink cups demanded 137,500 tons, or three percent of HDPE consumed.
- Sixteen percent (907,000 tons) of HDPE used in 1996 was made into film for use in food packaging, bags, and other uses. This film is produced in the form of a tube by blowing air through plastic extruded from a circular die.
- Seven percent (417,000 tons) of HDPE used in 1996 was extruded into pipe and conduit by pressing molten plastic through a circular die using a continuously revolving screw.
- Manufacturers used one percent (63,500 tons) of HDPE in 1996 to rotomold medium to large size hollow parts, containers, tanks and other items with relatively uniform wall thicknesses. Rotomolding is a process in which a mold filled with powdered plastic is heated while rotating simultaneously about two axes perpendicular to each other. After the plastic coats the inside mold surface, the mold is cooled and the part removed.

Figure 2. End-Use Manufacturing of HDPE in 1996 (Tons)

End Use	United States	North Carolina
Film	907,000	25,200
Food packaging	85,000	2,400
All other	822,000	22,900
Injection Molding	1,056,000	29,400
Industrial and shipping pails	395,000	11,000
Housewares	65,000	1,800
Crates and totes (incl. beverage cases)	144,000	4,000
Toys, novelties, sporting goods	43,000	1,200
Caps and closures	54,000	1,500
Food tubs/containers and drink cups	137,500	3,800
All other	217,500	6,000
Blow Molding	1,960,500	54,500
Liquid food bottles	641,000	17,800
Household chemical bottles	497,500	13,800
Industrial drums	133,500	3,700
Pharmaceuticals, cosmetics & toiletries	145,500	4,000
All other	543,000	15,100
Rotomolding	63,500	1,800
Pipe and Conduit	417,000	11,600
Corrugated	56,000	1,600
Gas distribution	95,000	2,600
All other	266,000	7,400
All Other HDPE	1,232,500	34,300
Total HDPE	5,636,500	156,800

Source: Society of the Plastics Industry, "Selected End-Use," *Facts and Figures of the U.S. Plastics Industry*, p. 69. Data are converted to tons from millions of pounds in the original. Numbers in subcategory might not add to number in total category due to rounding.

According to research findings published in *Modern Plastics*, over 1.2 billion pounds of HDPE (representing a 0.1 percent decrease since 1996) was used in liquid food bottles (primarily milk jugs). Another 1.05 billion pounds of HDPE (representing a 5.4 percent increase since 1996) was used in chemical bottles (primarily household products) in 1997.¹

Future Generation

HDPE has not seen the same dramatic growth in packaging market share as PET. Future generation of HDPE waste can be estimated by the projected future use of HDPE (both virgin and recycled) in non-durable goods. SPI data provide growth rates for liquid food bottles (between -0.9 and 8.6 percent), household chemical bottles (between -3.6 and 8 percent) and extruded film (between 2.7 and 20.7 percent). These figures are presented in Figure 3.

SPI figures indicate total sales and captive use of HDPE (both virgin and recycled) increased at rates between -0.6

and 12.3 percent annually from 1992-1997. (See Figure 4.)

Figure 5 presents estimates of North Carolina's share of plastics generated through 2002 using EPA's 1996 numbers and a 4 percent annual growth rate. This growth rate was based on the average growth in liquid food bottle use and the highly variable extruded film use of HDPE. The most readily recoverable components of the HDPE waste stream (shaded in Figure 5 and including "soft drink bottle base cups," "milk and water bottles," "other plastic containers," and "bags, sacks, and wraps") total a generation of 51,800 tons in 1996 and estimated generation of 65,500 tons in 2002.

Recovery

According to RW Beck, national recovery of HDPE was 330,000 tons, or 660 million pounds, and HDPE recovery increased by 62 percent between 1992 and 1996.² Using RW Beck's national numbers, a population based es-

Figure 3. HDPE Growth by End Use (virgin and recycled)

Year	Liquid Food Bottles		Household Chemical Bottles		Extruded Film	
	(Millions of pounds)	Percent increase over previous year	(Millions of pounds)	Percent increase over previous year	(Millions of pounds)	Percent increase over previous year
1992	1048		915		1089	
1993	1113	6.2	901	-1.5	1292	18.6
1994	1191	7.0	955	6.0	1560	20.7
1995	1180	-0.9	921	-3.6	1602	2.7
1996	1282	8.6	995	8.0	1814	13.2

Source: Society of the Plastics Industry, "Selected End-Use," *Facts and Figures of the U.S. Plastics Industry*, p. 69.

Figure 4. Sales and Captive Use

Year	Millions of pounds	Percent increase over previous year
1992	10110	
1993	10604	4.9
1994	11910	12.3
1995	11837	-0.6
1996	13211	11.6
1997	13482	2.1

Source: Society of the Plastics Industry, "Selected End-Use," *Facts and Figures of the U.S. Plastics Industry*, p. 69 for 1992-1996 and Society of the Plastics Industry web page for 1997 figure: <http://www.socplas.org/industry/stat3.html>.

Figure 5. HDPE Generation in North Carolina (Tons)

Product Category	North Carolina generation 1996	North Carolina generation 2002
Durable goods	12,500	15,800
Trash bags	6,400	8,100
All other non-durables*	9,700	12,300
Soft drink bottle base cups	600	800
Milk and water bottles	18,100	22,900
Other plastics containers	18,600	23,500
Bags, sacks, and wraps	14,500	18,300
Other plastics packaging**	34,200	43,300
Total Generated HDPE	114,600	145,000

* Includes plastics in disposable diapers, clothing, footwear, etc.

** Other plastic packaging includes coatings, closures, caps, trays, shapes, etc.

Source: US EPA, *Characterization of Municipal Solid waste in the United States: 1997 Update*

estimate of recovery in North Carolina is 9,200 tons. According to APC, 24.4 percent of all HDPE bottles were recycled in 1996.³

A majority of HDPE recycled in North Carolina is collected in local government programs. Figure 6 presents the tonnages of HDPE recovered by these programs since 1992-93. The materials recovered are typically milk jugs and other household HDPE bottles. The drop in HDPE recovered in fiscal year 96-97 by local governments is explained by two factors. Low market prices for some resins has caused some local government programs to scale back

or drop their plastics collection efforts. In addition, fiscal year 96-97 data included some reporting of commingled recyclables, which are not reflected in these numbers. The 1996-97 recovery was probably closer to 6,000 tons.

North Carolina local governments recovered about two-thirds of the national average for recovery based on its population according to the RW Beck figure presented above. At 6,000 tons, the recovery rate for these materials was 32 percent of the North Carolina generation of "soft drink bottle base cups" and "milk and water bottles" based on EPA data, or 12 percent of the North Carolina generation of "readily recoverable" items identified in Figure 1.

Figure 6. North Carolina Local Government Recovery of HDPE (Tons)

	FY 1992-93	FY 1993-94	FY 1994-95	FY 1995-96	FY 1996-97
HDPE	3,501	4,118	5,390	6,046	4,240

Source: NC DENR, *NC Solid Waste Management Annual Report: July 1, 1996 to June 30, 1997.*

Figure 7. North Carolina Estimate of Generation and Recovery Rate for HDPE Bottles in 1996

	Liquid Food Bottles	Recoverable Packaging
Estimate of Generation	37300* tons	51,800** tons
Recovery (public and private)	9000 tons	9000 tons
Recovery Rate	24 %	17 %

*Calculated from EPA data based on North Carolina population

**Calculated from EPA data based on North Carolina population. Recoverable packaging defined as ("soft drink bottle base cups," "milk and water bottles," "other plastic containers," "bags, sacks, and wraps," and "other plastics packaging").

Eight private recyclers reported recovery of roughly 3,000 tons of HDPE from North Carolina's waste stream. This recovery includes film as well as bottles. Adding this to the local government recovery yields roughly 9,000 tons of HDPE recovered, or 17 percent of the 51,708 recoverable tons identified from EPA data (see Figure 7).

MARKET DYNAMICS: PRICES AND CAPACITY

The two major components of market dynamics are prices and capacity. The relationship of these two factors to market dynamics for plastics overall is described in the introductory section to this chapter.

Prices

As with other plastic resins, the price paid for recycled HDPE resin usually remains below the price for competing virgin, pre-consumer, and off-spec resin. This price differential creates a barrier for post-consumer resins, because many purchasers would rather buy off-spec (which they perceive to be higher quality) than post-consumer when prices are similar.⁴

As with PET, recycled HDPE prices correlate strongly to virgin resin prices. Downward trends in late 1997 reflected switchovers to off-spec virgin from recycled by some major end-users. Figures 8, 9, and 10 present the price histories for virgin and recycled resins for common recycled products (milk jugs, detergent bottles, and plastic grocery bags).

Figure 8 compares the price of virgin HDPE used to make milk bottles to recovered natural HDPE pellet and flake.

Figure 9 compares the price of blow molding copolymer commonly used in shampoo and detergent bottles to recovered mixed color HDPE pellet and flake.

Figure 10 compares the price history for virgin high molecular weight (HMW) extrusion film to post consumer HMW-HDPE film pellets.

DEMAND

According to some sources, demand for recycled HDPE resin is expected to increase substantially in the future. The Freedonia Group, in a report entitled *Plastic Recycling to 2000*, provides the nationwide estimates listed in Figure 11. The figure shows an optimistic view of recycled HDPE demand into the next century: not only is the raw tonnage estimate of recycled demand rising, it is also rising in relation to overall virgin plastic demand.

Market end uses for HDPE increased from 1996 to 1997 as represented in Figure 12.

While some smaller recycling companies are going out of business, large recycling companies are expanding during the soft market in order to increase market share in anticipation of projected stronger markets to come.⁶ This is the case for KW plastics of Troy, Alabama. "HDPE reclaimers already possess a high level of excess capacity, and more capacity is expected. KW Plastics plans to be one of the world's largest reclaimers of plastic bottles. The firm is expanding its HDPE bottle processing capacity to 650 million pounds per year and adding 50 workers. Alone, KW plastics could handle more than 80 percent of the current recovery volume."⁷ KW recycles equal amounts of natural and mixed-color post-consumer HDPE. About 70 percent of its pellets are sold to the blow molding industry. Other end markets include curbside collection carts, T-shirt bags, strapping and hangers for plastic bags.⁸

By the end of 1998, Earth Care Inc. of Tennessee, will have the capacity to produce 500,000 railroad ties per year, using 100 million pounds of post-consumer and post-industrial high density polyethylene.⁹

Figure 8. HDPE Price Histories (Homopolymer & Recycled Natural)

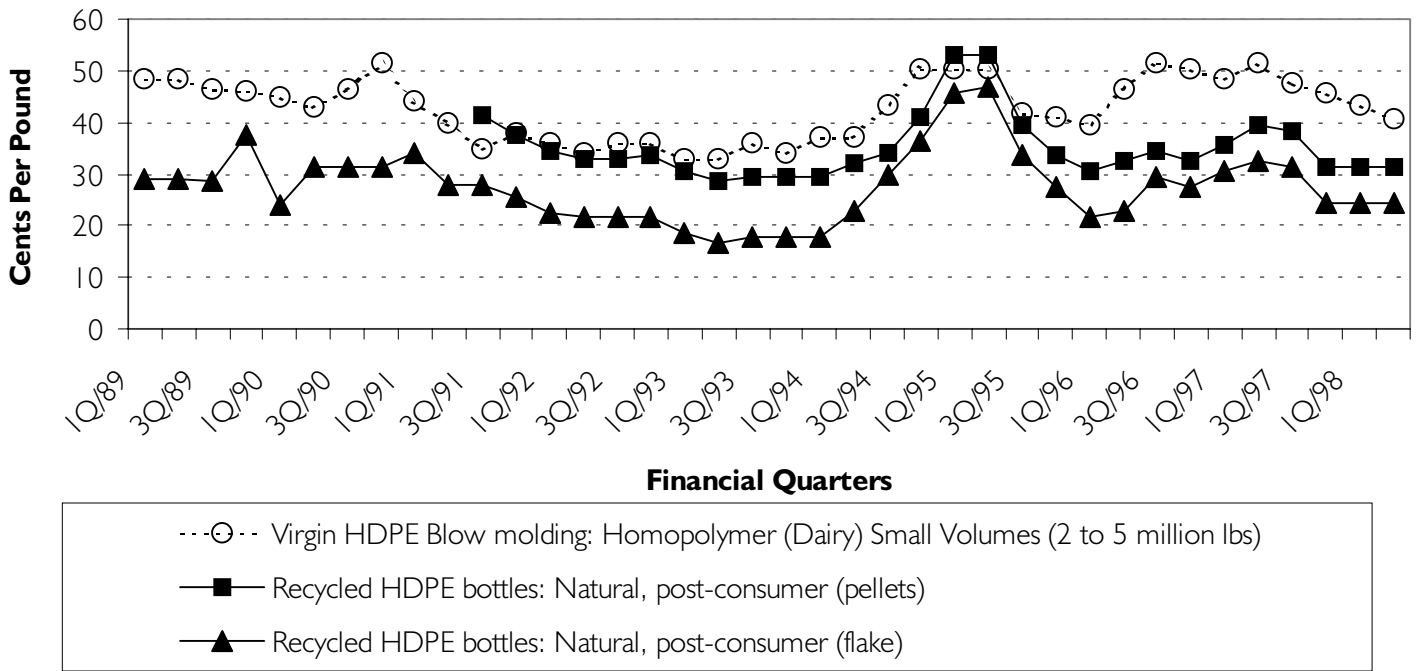
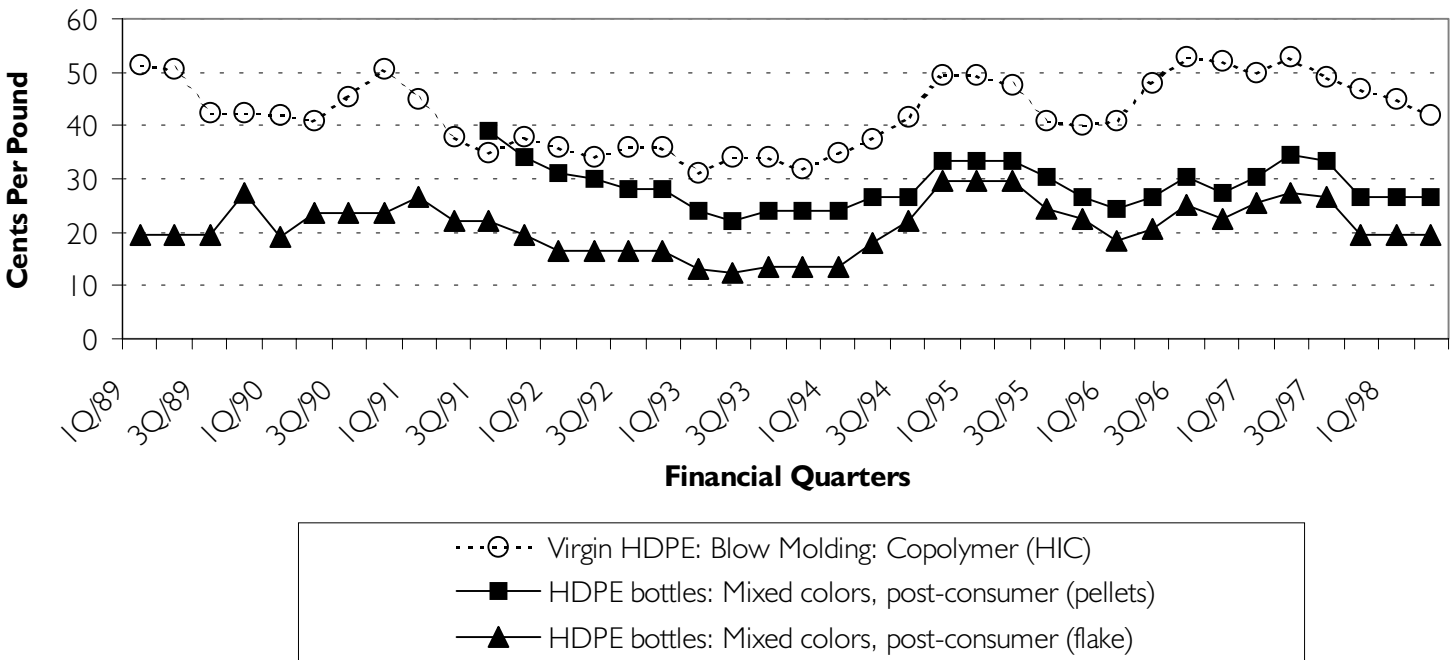


Figure 9. HDPE Price Histories (Virgin Copolymer & Recycled Mixed Colors)



SUPPLY / DEMAND RELATIONSHIP

Figure 13 attempts to characterize the “marketability” of North Carolina generated HDPE by comparing Freedonia’s nationwide demand projections to the estimates of HDPE supply in the state. North Carolina’s generated HDPE would obviously be competing with generated HDPE from other

states and countries. The lower the percentage of North Carolina tons to total demand, theoretically the better chance North Carolina tons have of being successfully marketed. Factors such as proximity to market and resin price must also be considered when characterizing the marketability of North Carolina generated HDPE.

Figure 10. HMW Price Histories (Virgin & Recycled)

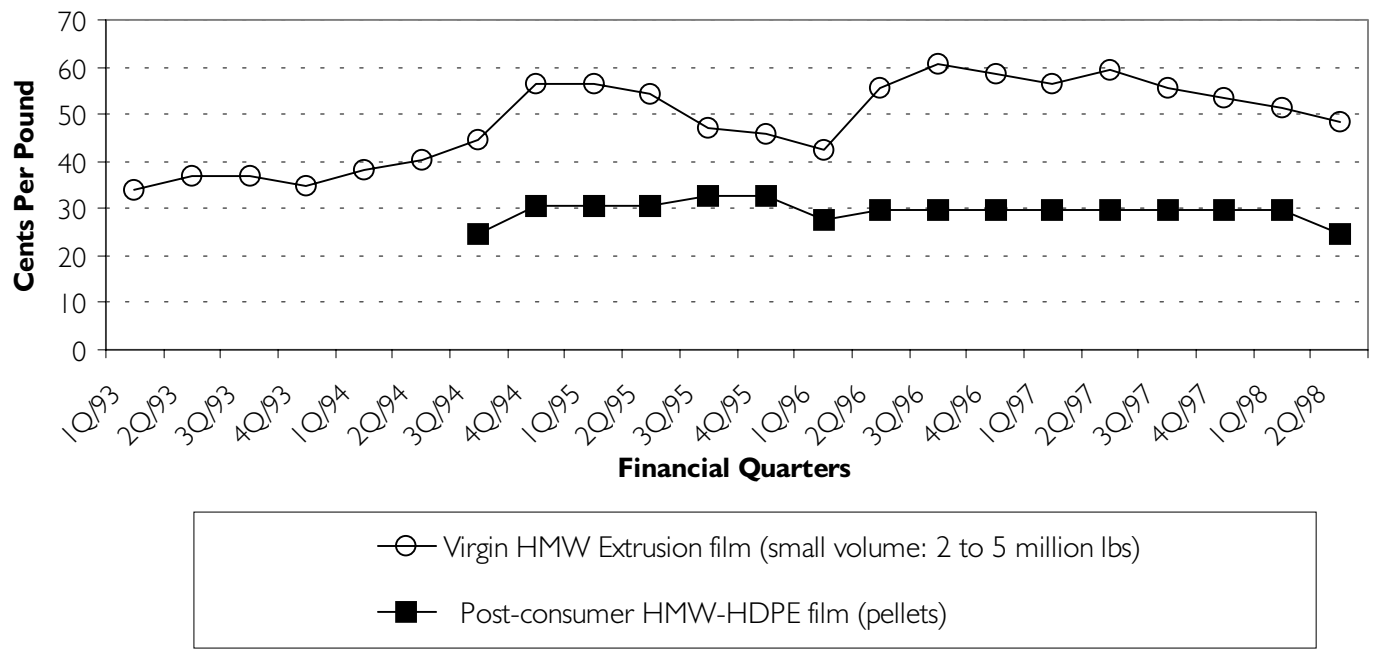


Figure 11. Demand for Recycled HDPE to 2005 (tons converted from lbs. in original)⁵

	1985	1989	1995	2000	2005
Recycled HDPE demand	22,500	62,500	300,000	475,000	730,000
Percentage growth rate from previous listed year	NA	177%	380%	58%	54%
Overall virgin plastic demand	22,100,000	26,900,000	35,550,000	41,800,000	48,300,000
Recycled HDPE as a percentage comparison with virgin plastic demand	.10%	.23%	.84%	1.13%	1.5%

Figure 12. Recovered Resin End Uses (tons)

Reclaimed resin end-use market	Reclaimed resin end-use market capacity 1997	Change from 1996
Recycled bottles	102,500	-4.7%
Drainage pipe	52,500	-4.5%
Film	61,000	+8.9%
Pallets	49,000	+30.7%
Plastic lumber	37,000	+5.7%
Export	13,500	-22.9%
Other	44,500	+1.1%
Total	360,000	+2.1%

Source: "Plastics Use Rises," *Resource Recycling*, v. 17, n.2, Feb. 1998, p. 11. (converted to tons)

Specific processing capacity in the Southeast region (defined as Maryland, Virginia, North Carolina, South Carolina, Kentucky, Tennessee, Georgia, Florida, and Alabama) provided by APC is presented in Figure 14.¹⁰

HDPE Film

About 70 percent of all plastic grocery sacks are HDPE; the remaining 30 percent are an equal mixture of LDPE and LLDPE. These HDPE bags are largely sought after by plas-

Figure 13. Future Marketability of North Carolina HDPE

	1996	2002
Estimated North Carolina generated tons*	51,560	65,800
Freedonia demand estimate**	335,000	577,000
North Carolina generated tons as a percentage of projected overall demand	15%	11%

*Estimated generation from "recoverables" in Figure 5.

** Numbers for Freedonia interpolated to match years for generated estimates.

Figure 14. Processing Capacity for HDPE in Southeast Region

	Tons
Wash Capacity	240,000
Dry Reclaim Capacity	50,000
Total Resin Capacity	290,000

tic lumber and wood/plastic composite lumber manufacturers. Ron Perkins of APC speaks about the tight market for this material in a recent *Plastics News* article: "Plastic lumber maker Trex Co. in Winchester, Virginia, is having problems finding supply, and paper and wood firm Boise Cascade Corp. of Boise, Idaho, is evaluating whether it economically can collect the 10 million pounds of film a month it needs in the Pacific Northwest to recycle into a wood-polymer composite siding."¹¹

Mike Vatuna, purchaser for Trex (a plastic lumber manufacturer), says that their use of polyethylene film increased from 3.25 million pounds per month in January of 1997 to 6.5 million pounds per month in June of 1998.¹² In 1996 Trex bought 51 percent of all grocery bags collected nationwide. Mr. Vatuna also indicates that export markets are strong for this material. According to Vatuna, prices are rising due to low collection rates and the fact that virgin polyethylene resin price is currently up. The strongest collection programs are in the Northeast, so that is where most of Trex's material is sourced. Trex also consumes about 20 percent of the stretch film recycled in the United States. The other component in their product is waste wood, mostly from furniture makers.¹³

As reported in *Plastics News*, another southeastern manufacturer, Mid South Extrusion Inc. of Monroe, Louisiana, is "expanding both its capacity and its market reach for film while centralizing its new recycling operations. Film capacity of 26 million pounds will expand to 40 million pounds of high, low and linear low density polyethylene annually."¹⁴

CONCLUSION

Due to more-than-adequate capacity for processing and end use of HDPE resin, recovered HDPE prices are not likely to drop with increased collection of this resin. Increase in recovery will most likely be accompanied by lower per ton collection and processing costs, thus increasing the profit on recycling this material.

There is room for growth in the collection and recycling of blow-molded bottles and film extruded bags already collected in North Carolina. In addition, there are other identifiable and separable HDPE products that should be considered for collection and recycling. These include injection molded industrial and shipping containers (11,000 tons per year in 1996 in North Carolina) and food tubs per containers and drink cups (3,800 tons per year in 1996 in North Carolina) as identified in Figure 2.

The ability of HDPE markets to handle the current and projected supply of material generated in North Carolina appears to be more than adequate. However, the price paid for recycled HDPE is based to a large extent on the capacity and price paid for virgin HDPE at any given point. For there to be consistent, long-term increases in the recovery of HDPE resin, a commitment must be made by industry to make the purchase of recycled HDPE a priority. At the same time, state and local governments, along with private collectors of recycled materials, should make every effort to provide their citizens/customers with incentives and services that maximize the recovery of HDPE. In addition, governments and individuals need to close the recycling loop by purchasing products made from recycled HDPE.

RECOMMENDATIONS

The following recommendations are based on the study of generation, recovery and markets for HDPE in North Carolina presented in this section.

- The plastics industry should continue to provide technical assistance to communities on ways to recover more plastic bottles, including researching ways to reduce collection and processing costs.
- The plastics industry should do more to fulfill growing demand for HDPE resin from recycled sources rather than virgin, helping to avoid the market situation that occurred in 1995-96. Capacity shifts from virgin to recycled, or at least meeting new HDPE resin demand with recycled resin, will strengthen and stabilize HDPE markets and send strong signals to collectors and processors to recover more HDPE.
- North Carolina's local governments should reinvigorate their efforts to recover HDPE bottles, including enhancing participation in current collection programs and targeting new areas for collection. Improved education and promotion, plus implementation of Pay-as-You-Throw programs (unit or variable rate pricing), should be important aspects of these efforts. Increased recovery can be realized through collection of all plastic bottles and use of plastic compaction on collection vehicles, and improved recovery can decrease the per ton cost of collection of plastics.
- The state should also consider increasing the availability of financial incentives to enhance HDPE recovery and use, including grant funding for capital purchases that improve collection efficiencies and economic development incentives or technical assistance for HDPE end-users to use recycled HDPE.
- If consistent improvement in HDPE recovery is not achieved by 2002, the state should consider implementing statutory mechanisms such as take-back requirements (e.g., bottle bills), mandated recycled-content targets, and other command-and-control approaches.

¹"Plastics use rises" Resource Recycling, Feb 1998, p. 11.

² Lucyshyn, J. and Craggs, R. "A five year history of recycling market prices: 1997 update", *Resource Recycling*, Feb. 98, p. 19.

³ Society of the Plastics Industry, *Facts & Figures of the U.S. Plastics Industry, 1997 Edition*, page 91.

⁴ Smith, Sarah S., "Recyclers Looking Up, Despite Downside" *Plastics News*, January 19, 1998, p10.

⁵ <http://freedoniagroup.com/ppv-scripts/>

⁶ Smith, Sarah S., "Recyclers Looking Up, Despite Downside" *Plastics News*, January 19, 1998, p10.

⁷ "Plastics bottle recycling capacity on the rise," *Resource Recycling*, January 1998, p 64.

⁸ Smith, Sarah S., "PE Recycler Expanding", *Plastics News*, November, 17, 1997.

⁹ Smith, Sarah S., "Recyclers Looking Up, Despite Downside" *Plastics News*, January 19, 1998, p10.

¹⁰ Dunbar, Judy, American Plastic council, personal communication, July 14, 1998.

¹¹ Toloken, Steve "Supply vs. Demand Stirs Recycling Debate", *Plastics News*, May 25, 1998, p. 13.

¹² Mike Vituna, Trex, personal communication June 11, 1998.

¹³ Urey, Craig "Plastic Stacks up Admirers as Alternative Deck Material" *Plastics News* June 15, 1998, p.1.

¹⁴ Urey, Craig, "Mid South Extrusion Expanding, *Plastics News*, November 3, 1997, p. 3.