Part I

Mixed Plastics Recycling—Characterization, Collection, Costs, Markets

The information in Part I is from *Post-Consumer Mixed Plastics Recycling–Characterization, Collection, Costs and Markets,* prepared by Bruce A. Hegberg, William H. Hallenbeck, and Gary R. Brenniman of the University of Illinois Center for Solid Waste Management and Research for the Illinois Department of Energy and Natural Resources, Office of Solid Waste and Renewable Resources, January 1991.

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This public service report is a result of the concern of the Illinois Governor, State Legislature, and the Public for the magnitude of the solid waste problem in Illinois. The concern led to the passage of the Illinois Solid Waste Management Act of 1986. One result of this Act was the creation of the University of Illinois Center for Solid Waste Management and Research. The Office of Technology Transfer (OTT) is part of this Center. One of OTT's means of transferring technology is the publication of pubic service reports which contain discussions of important topics in solid waste management.

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Summary

Recycling of plastic discards is one method of reducing municipal solid waste. They are beginning to join glass, steel, aluminum and paper as waste stream components that have been accepted into recycling programs across the country. It is difficult, however, to expand post-consumer plastics recycling beyond the easily recognized milk jugs and soda bottles because of the variety of plastic wastes, the difficulty of sorting plastic resins, the low density of post-consumer plastics wastes and the limited history of plastics recycling. However, in order to expand the recovery and recycling of plastics and decrease the amount of waste disposed in landfills, it will be necessary to overcome these difficulties. Because of its heterogeneous nature and the amount of contaminants present, separation of post-consumer mixed plastic waste is the most difficult. The term "mixed plastics," a mixture of plastic resins or a mixture of package/product types which may or may not be the same plastic type or color category, has been used to describe broad scale processing of post-consumer plastic waste. Mixed plastics also includes products which may be the same resin type but which have been fabricated using the differing manufacturing techniques. The purpose of this report is to identify the compositions of plastics in municipal solid waste (MSW) and in recycling programs, the post-consumer plastics contributions to recycling programs, the cost of plastics collection and some of the end uses for reprocessed post-consumer plastics. Attention is given to curbside collection of recyclables because of its high recovery rate (60-90%) in comparison to other recycling methods (10-30%).

The 1989 production of plastic resins in the U.S. totaled 58.2 billion pounds. Almost all of the annual production (92%) was consumed in the U.S. Eight resin types make up 83% of the annual domestic demand: low density polyethylene (LDPE), 9.7 billion lbs; polyvinyl chloride (PVC), 7.6 billion lbs; high density polyethylene (HDPE), 7.4 billion lbs; polypropylene (PP), 6.2 billion lbs; polystyrene (PS), 5.0 billion lbs; polyurethane (PUR), 3.2 billion lbs; phenolic, 3.1 billion lbs; and polyethylene terephthalate (PET or PETE), 1.9 billion lbs. The packaging sector is the leading consumer of plastic resins at about 14 billion pounds annually.

A relatively small amount of plastic is recycled on an annual basis in comparison to the production levels of plastic resins or the amount disposed in MSW landfills. It has been estimated that 340-400 million pounds of plastics were recovered or recycled in some fashion in 1989. Approximately 29 billion pounds were disposed in MSW. About half of the recycled plastic came from the recycling of PET beverage bottles (including the HDPE base cup on such bottles), and most of the remainder came from HDPE bottles, PET x-ray film and PP car battery cases. The amount of plastics recycled in comparison to the amount disposed is 1.3%, and in comparison to the annual production level of plastics in the U.S. is 0.6%. A review of the 15 primary resins produced in the U.S. shows that five of the above mentioned resins are disposed of primarily through MSW, and that the remaining plastics are generally destined for non-MSW disposal, i.e.

imports/exports of plastics, recycling, construction/demolition debris or incineration. PVC is the only major resin which is not primarily disposed through residential, commercial or institutional MSW.

To help increase the recycling of plastics in Illinois, the state passed legislation requiring the labeling of six plastic types on all plastic bottles with a capacity of 16 fluid ounces or more and on all other rigid plastic containers with a capacity of 8 fluid ounces or more (PETE - 1, HDPE - 2, PVC - 3, LDPE - 4, PP - 5, PS - 6, and all others - 7). Many manufacturers are now voluntarily labeling their packaging with the appropriate number, even though not required by law. A law has also been passed which requires all counties to develop plans which will achieve 25% recycling. Increasing the recycling of these six primary plastics is a logical next step in satisfying the state law to achieve 25% recycling.

There is a wide variation in the types of plastics currently collected in curbside recycling programs. While some communities collect clear HDPE beverage bottles and/or PET beverage bottles, others have moved beyond this to additionally collect colored HDPE bottles (typically household chemical bottles), any type of plastic bottle, any type of rigid plastic container (RPC), or any plastic with the previously mentioned 1 through 7 numbering system. As part of pilot programs, some communities have started collection of non-bottle packaging such as foam PS and LDPE six-pack rings.

Collection of any type of cleaned plastic, including films, has been conducted in pilot programs and continues in municipalities near "plastic lumber" manufacturers. Towns around Toronto, Canada, on Long Island, New York, in central Michigan, and in northwestern Iowa are areas where such mixed plastic collection is being done. Previous attempts at such extensive mixed plastic collection have not always been successful due to a high reject rate of unacceptable materials (such as rubber hoses and household medical waste), and due to food and container content contamination. The result is a high cost for manual sorting. Resident education, including cleaning and proper preparation of recyclable plastic, was a key element often cited as a method to resolve these problems.

In 1989 it was estimated that 9 million U.S. households were part of curbside recycling programs and that 20% collected some type of plastic. Twenty percent of U.S. households are projected to have curbside collection by 1992 with an annual plastics collection of 334 million pounds. In Illinois by the end of 1990, 600,000 households were expected to have curbside recycling. It is currently estimated that 43 municipalities in Illinois collect some type of plastic, affecting a total of 221,000 residences. Of these, approximately 40% collect some type of mixed plastic. None of the curbside programs in Illinois collect LDPE films and only a few collect RPC or any type of plastic bottle.

A review of plastic in MSW indicates that plastics comprise 6 to 10% of MSW by weight and that the largest constituent is LDPE (film and rigid plastic containers) followed by HDPE. A

waste composition analysis for the city of Chicago determined 9.4% by weight of its MSW was plastic. Plastics generally occupy 20% by volume of landfill discards.

Although LDPE is the primary constituent of plastic in MSW, little film plastics (LDPE) recycling is done. Little data is available on post-consumer collection of LDPE. When LDPE is collected in recycling, it can be expected to comprise 25% by weight of the plastics collected.

There are large variations in the composition of plastics collected and the amount collected per household on a weight basis. For a municipality considering collection of mixed plastics, it is best to conduct a pilot program in a test area(s) whereby composition and generation rates can be developed. When measurement of plastic recyclables is based on the entire number of residences in a collection area and includes participants as well as non-participants, the unit "lb/collection area household/year" is used. Generally, collection of RPC will result in 30 lb/collection area household/year (lb/cahh/yr), while collection of plastic bottles will result in 20 lb/cahh/yr, as a minimum. Collecting only clear HDPE (milk) bottles will obtain 5-7 lb/cahh/yr; adding colored HDPE bottles will add another 1-4 lb/cahh/yr; collecting PET bottles will obtain another 2-5 lb/cahh/yr; and collecting PS can obtain 5 lb/cahh/yr. Examining household generation in this fashion will provide an indication of the overall effectiveness of a curbside recycling program with regards to participation and recycling education.

Actual recycling rates for plastics based on only participants which set plastics out at curbside are significantly higher. When measurement of plastic recyclables is based only on the residences in a collection area which participated in plastics recycling, the unit "lb/participant household/year" is used. This type of measurement more appropriate for comparison among curbside recycling programs than measurements which factor in non-participants. Contribution of just HDPE bottles has been shown as high as 35 lb/participant household/year (lb/phh/yr), and PET has been shown at 23 lb/phh/yr. It is further estimated that 6 lb/capita/yr LDPE, 3.5 lb/capita/yr PP and 1.5 lb/capita/yr PVC can be collected in residential recycling. These values can provide an estimate of the actual potential for recycling in an area if all or most residences were to participate in a curbside recycling program. Collection of any type plastic bottle will result in a 75 to 200% by weight increase over the amount collected if only PET and clear HDPE beverage bottles were in a plastics recycling program.

Contamination of non-specified plastic and non-plastic contaminants are usually present in collected plastics. Non-specified plastics range from as little as 1% for relatively simple plastics collection to as much as 10 to 20% for plastic bottle or colored HDPE bottle recycling. Non-plastic contaminants will comprise anywhere from 1 to 10% contamination by weight. Education is the most important way to keep contamination levels down.

The cost associated with plastics recycling depends on many variables such as equipment used, collection methods, collection frequency and material collected. Automation of collection and processing methods have been and continue to be a barrier in reducing the cost of plastics recycling. Generally, the cost of weekly curbside recycling ranges from $12 to $30/household

served/year. Collecting weekly rather than biweekly will add 10 to 35% to the cost of curbside collection. There is little information regarding the incremental cost associated with collecting types of plastics. One series of pilot projects determined that adding collection of clear HDPE and PET beverage bottles to a 50,000 household program would cost $0.70 to $1.40/household served/year (using curbside sorting). The cost of adding collection of all plastic bottles, RPC, or clear/colored HDPE and PET bottles would be $3.30 to $4.30/household served/year (also using curbside sorting). None of these values include the cost savings associated with diversion credits or revenue sales, and they also do not include the cost of processing. The cost of baling sorted plastic is estimated at 3 to 4¢/lb. The cost of processing commingled plastic at a sorting and baling/grinding facility is estimated at 10 to 12¢/lb.

Computer programs which assist in solid waste planning and recycling costs are available from the IDENR and from the National Association for Plastic Container Recovery. Another method of solid waste cost planning called "least cost scheduling" uses linear programming to minimize the costs associated with recycling, waste disposal and landfilling. It can also be utilized for cost estimating recycling programs.

The market outlook for recycled plastics is strong. The recycled resin demand for the six previously mentioned plastics (HDPE, LDPE, PET, PP, PS and PVC) by the end of 1993 are expected to be 3.5 times that of 1990 levels. The price of sorted, baled plastic is currently in the range of 7 to 12¢/lb and the price of sorted, cleaned and flaked plastic is 20 to 30¢/lb. Pelletized recycled resin ranges from 20 to 45¢/lb.

To increase the amount of collected plastic, reduce the cost associated with waste plastic processing, and increase the market prices for recycle resin, changes in packaging design are taking place. This includes using reusable packages, using single material packaging wherever possible, using materials that are either easily separated or compatible if a single material cannot be used, using recycled materials where possible, and eliminating toxic constituents from packaging.