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For further information about these reports, please contact the following:
London, Dr. Alexander Coker, Manager PERP Program, phone: + 44-207 950-1570, e-mail: acoker@nexant.com.
New York, Heidi Junker Coleman, Multi-client Programs Administrator, phone: + 1-914-609-0381, e-mail: hcoleman@nexant.com.
Bangkok, Maoliosa Denye, Marketing Manager, Energy & Chemicals Consulting: Asia, phone: + 66-2793-4612, e-mail: mdenye@nexant.com.
Website: www.chemsystems.com

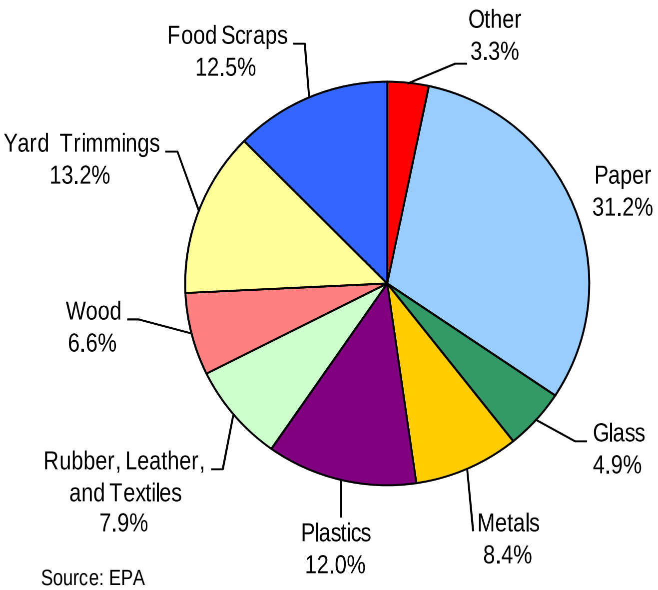
INTRODUCTION

There are several approaches to dealing with the problem of waste disposal, in particular waste generated by plastics. These approaches include source reduction, recycling, incineration, and landfilling. Recycling is considered the best option to reducing the volume of solid waste, second only to source reduction (which is accomplished by generating less packaging in the first place and/or reusing it in the same service). Recycling reduces landfill requirements and the consumption of virgin material resources. Perhaps most importantly in these energy-conscious times, the energy required to recycle many materials is substantially less than the energy consumed in producing them from virgin resources.

Using the United States as an example, the figure below shows a breakdown of the sources of municipal solid waste generation in the United States in 2008.

United States Solid Waste, 2008

(Total: 250 million metric; before recycling)



Source: EPA

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About 33 percent of this municipal solid waste was recycled, 13 percent was incinerated, and 54 percent was landfilled. This is in marked contrast to less than 10 percent recycling and 80 percent landfilled in 1988.

Recycling of plastics bottles lends credence to the argument that the “feedstock” energy is not actually consumed but merely “borrowed”, (i.e., available for use again). In particular, the rapid success of PET soft drink bottles created a great deal of controversy over the energy implications of bottle disposal.

Post-consumer plastics recycling technologies have evolved from traditional plastics processing and/or industrial scrap molding technologies. The challenge has been to modify these technologies to accept heterogeneous mixtures of plastic resins, normally incompatible with one another, and to tolerate contamination by various non-plastic materials.

The recycling technologies available today can be divided into four broad categories:

- Separation that mechanically segregate distinct resins from a mixed-plastic stream
- Mixed plastic that use the mixed-plastic stream as is
- PET recycling for beverage bottles
- Washing/upgrading for previously sorted plastics (e.g., HDPE dairy bottles)

Separation technologies segregate high-value (i.e., high-volume) plastics (e.g., the polyolefins) from other plastics. The system first separates the mixed plastics from contaminants (e.g., paper, glass, metals, dirt, etc.). Once separated, the mixed plastics are chopped or granulated, followed by washing, separating by the sink/float process (i.e., difference in density) or hydrocycloning (centripetal acceleration separation by density), drying, and pelletization. The pellets are cooled and dried, again producing an end product ready for shipment as feedstock to make new products. A typical mixed waste stream would have a polyolefin fraction of 60 to 80 percent, 15 to 30 percent heavier plastics (e.g., PVC, ABS, polystyrene, PET), and five percent aluminum, paper, and other inorganics.

RECYCLING TECHNOLOGIES

The recycling of PET, primarily from beverage bottles, has progressed faster than for the other plastics with most of the PET being recycled for fiber applications (such as carpets and textiles). In 2008, the United States recycled approximately 3.7 percent of the plastics that were generated, where about 27 percent constituted PET bottles and jars and 29 percent plastic HDPE natural bottles.

This section reviews the technical features of selected PET bottle to bottle recycling technologies.

- SUPERCLEAN (OR PHYSICAL): SECONDARY RECYCLING

  The recycle of PET bottles is normally done by sorting and washing the bottles, grinding into flakes, washing the flakes, removal of labels and caps, and drying the flakes. An optional step (which depends on the end use application) includes melting or extruding the flakes into PET pellets. The rPET produced this way is suitable for fibers and non-food contact bottle applications. If the flakes are intended for the manufacture of bottles utilized in food applications then the normal process would require an extra step in which volatile contaminants are removed while at the same time increasing the intrinsic viscosity of the flake. In this case, the recycling process is referred as a “Superclean” process. Superclean process technologies are reviewed including mechanical washing systems and various company specific processes (e.g., Vacurema, Krones, OHL, Starlinger etc.)

- FEEDSTOCK (OR CHEMICAL): TERTIARY RECYCLING

  In contrast, tertiary recycling involves chemical or thermal manipulation to process a stream of PET waste. The chemical structure of the PET break downs (known as depolymerization) and reverts back to the basic monomers or oligomers, which can then be purified and recombined to produce new PET resin. Conventional Tertiary Recycling Technology as well as various company variations (e.g., Hoechst Celanese, Mitsubishi Heavy Industries, United Resource Recovery Corporation) are reviewed.

ECONOMIC ANALYSIS

The development (and further commercialization) of PET recycling process are highly dependent on the economics of such processes. Unfavorable economics, when compared to the production of virgin PET resins, as well as market conditions are often the determinant factors for the introduction of new PET recycling process.

The issue of sufficient feedstock is also key to the success of any recycling venture. The recycler is concerned not only with the source of the material but must also consider the costs involved in bringing this material to the processing location. As the recycling business expands, the competition for feedstocks intensifies.

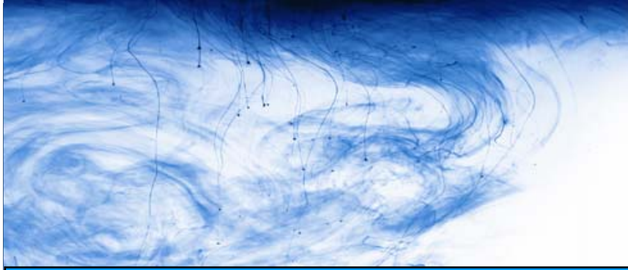
Several cases have been considered for the production of PET. These cases do not necessarily represent any one specific technology owner, but rather, represent “state-of-the-art” processes. Additionally, it has been assumed that the baled PET post consumer PET bottles consist of clear PET bottles. The selected cases are:

- PET Recycle Flake from Post-consumer Baled PET via Sort/Wash/Grind/Separate PET Bottles
- Recycled PET Pellets from Washed PET Flake via Superclean Process
- Recycled PET Flakes from Post-consumer Bottle PET via Superclean Process
- Virgin PET Bottle Chip Resin from PTA via Conventional Melt/SSP

COMMERCIAL MARKET

This section provides a regional market review for PET bottle grade for the United States, Western Europe, and Asia Pacific regions. The forecast timeframe is to 2014.

Tables detailing specific plant capacity, owning company, location, and processing technology utilized are given for each of the regions listed above. Supply, demand and trade tables for each regions are also given and discussed.



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