# INCENTIVES FOR RECYCLING AND REUSE OF PLASTICS

## A Summary Report

U.S. ENVIRONMENTAL PROTECTION AGENCY

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U.S. ENVIRONMENTAL PROTECTION AGENCY

1973

This summary is based on a 300-page report (SW-41c) entitled *Incentives for Plastic Recycling and Reuse* by ARTHUR D. LITTLE, INC., which is available as PB-214 045 from the National Technical Information Service, Department of Commerce, Springfield, Virginia. The full report includes 59 tables and 38 figures, and consists of these major sections:

- The Technology of Plastics
- The Economics of the Plastics Industry
- The Plastics Cycle
- Scrap and Nuisance Plastics Industry
- The Plastics Cycle
- Scrap and Nuisance Plastics: Isolation, Applications, and Markets
- Tactics and Strategies for Recycling

An environmental protection publication (SW-41c.1) in the solid waste management series

## SUMMARY

Plastics are one of the major materials in use today, and in the 1980's more products will probably be made from plastics than from any other material including steel. The production of plastics or resins was 20 billion pounds in 1970 and is expected to rise to more than 50 billion pounds per year by 1980. This rapid growth is due to the many advantages offered by plastics. They are lightweight and strong, they offer freedom in design and ease of fabrication and their cost is low.

At the disposal site, plastics represent an average of less than 2 percent of the solid waste stream today, and even at the projected rapid rate of growth of plastic use, plastic wastes are not expected to exceed an average of 3 percent by 1980. This projection assumes little or no change in the material composition of the solid waste stream. If, however, other materials such as paper, metal, and glass are recycled, the percentage of plastics in solid wastes will increase. But in contrast to the other major materials, plastics are not now being extensively recycled from the consumer. This study, therefore, examines the possibility of promoting the recycling of plastics--considering the technical and economic impediments; and it further provides the methodology for investigating other materials in the disposal area.

### Plastics Technology

Plastics are a family of synthetic materials composed of extremely large molecules called polymers, which are synthesized from simpler molecules called monomers. The overall properties of a plastic are a result of the combined properties of all its molecules, such as their different sizes, their chemical structure and shape, and their ability to crystallize. Furthermore, the properties of plastic materials can be altered by mixing them with additives. Additives are mixed or compounded with the polymer to improve its processing characteristics and produce other desirable properties. The resulting product is then called compound or resin. Resin is a general term that also denotes additive-free polymer.

Plastics are generally sensitive to environmental conditions, and particularly to oxidation. The net effect of weathering or reheating can cause the plastic to lose strength and to become embrittled and discolored. Because recycling plastics normally involves reheating, some reduction in the physical properties of the plastic occurs. To retard these effects, stabilizers are often added to most plastics.

Polymers that soften when heated and can be shaped if heat and pressure are applied are called thermoplastics. Polymers that soften and can be shaped only during the first heating cycle and cannot be reformed are called thermosetting plastics. Since thermosetting plastics are not easily recycled, this study was limited to thermoplastics, which today represent about 80 percent of all plastics. Some coatings and adhesives are thermoplastic, but they are impossible to recycle. When they are excluded, the percent of potentially recyclable thermoplastics remaining is 75 percent of all plastics, or approximately 15 billion pounds in 1970. This study was restricted to the five major thermoplastics: low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene, styrene polymers, and polyvinylchloride (PVC). These five represent 89 percent of all thermoplastics (excluding coatings and adhesives).

Resins are available in granulated, powdered, or pelletized form. The process of transforming them to a plastic or plastic-containing item is called fabricating, and the process of altering a fabricated plastic product by decorating, cutting, or sealing is called converting. Fabricating and converting are both examples of processing operations. Processing can also include reprocessing, which is the operation required to recycle scrap plastic (SP) into a useful plastic product.

In this study we use the term scrap plastic (SP) to denote all scrap that has value and is recycled, such as the scrap generated during the manufacture of resin and plastic items. This scrap may be in the form of contaminated compound, film trimmings, strands, or large chunks of plastic from the molding machinery.

Another term--nuisance plastic (NP)--is used to denote that portion of plastics production that has no value and is usually found in the disposal area. For example, the consumer generates NP when he disposes of his spent plastic products, and, if the manufacturer cannot use his scrap, it also becomes NP.

Reprocessed SP is called secondary resin and is used in fabrication. It competes with prime and offgrade virgin resins. Prime virgin resin meets the specifications required by the fabricated plastic product, whereas offgrade normally does not. However, offgrade can be used to fabricate plastic products that can tolerate raw materials having a range of physical properties.

Reprocessing or recycling is often an integral part of fabrication. Normally, the SP is reground and combined with the virgin resin in the fabrication process. An average of approximately 10 percent of the resin used in fabrication is recycled, although the amount can climb as high as 35 percent, depending on the requirements of the end plastic item. About 1.2 billion pounds of resin were recycled by the fabricator in 1970.

Reprocessing is also carried out by a special segment of the plastics industry--the reprocessor. He purchases scrap primarily from the resin producer and fabricator. The scrap varies by plastic type and form and is purchased for 0 to 10 cents per pound (the average price is approximately 4 cents per pound). About 1 billion pounds of SP are processed by the reprocessor annually, and over half of this volume is derived from the basic resin producers. The reprocessor, like the resin producer, sells his resin (secondary resin) to the fabricator.

One of the major functions of the reprocessor is to remove the contaminants from the scrap, and over the years he has developed a number of different methods for carrying out this process. He can also alter the melt flow characteristics of the resin by blending different lots and adding plasticizers. The principal difficulty in recycling or reprocessing plastics is that different polymers are generally not compatible with each other. Thus, segregation of the various plastics is required in most reprocessing operations.

## The Economics of the Plastics Industry

The cumulative value of shipments of all the products made and all the equipment used by the plastics industry was approximately $24 billion in 1970, and resins alone accounted for about $4 billion of this total. The raw materials used for the production of these resins are petrochemicals such as ethylene and styrene. Approximately $2 billion worth of these materials was used in the manufacture of resins in 1970. When combined with other basic materials (e.g., paper, textiles, and metals) and processed into semi-finished or finished products, these products have a value at the manufacturer's level of over three times the cost of the polymer and additives, or approximately $17 billion.

Integration among the various segments of the plastics industry, namely the resin producer, the fabricator, and the converter is very extensive. Nearly all resin producers are also manufacturers of fabricated products. Another 25 to 30 percent of all plastic materials is fabricated by the manufacturer/packager segment of the plastics industry, which assembles the plastic or plastic-containing product or fills the plastic container. In addition, over 2,500 independent fabricators, most of which are small, privately-owned businesses, process 40 percent of all resins.

The main factor in the spectacular growth in the use of plastics has been the continuing large decrease in the selling prices of the basic resins. For example, in 1961 the average price of LDPE--the major thermoplastic--was about 24 cents per pound; in 1971 it was 13 cents per pound. During the same period the price for offgrade LDPE dropped from about 19 cents to 9 cents per pound. But the price of secondary resin did not drop as rapidly. Secondary resin, which is made from scrap, competes with offgrade virgin resin, and in 1961 the difference between a secondary LDPE resin and the equivalent offgrade resin was 3 cents per pound; in 1971 the difference was 1 cent or less per pound.

This narrowing of the selling-price gap has acted as a major impediment to recycling plastics. Although the prices of virgin resins have been falling, rising costs of labor and distribution involved in reprocessing have prevented a similar decline in the price of secondary resins. Even if the reprocessor's raw material costs are negligible, his product cannot sell for much less than 5 cents per pound, which is the average conversion cost.

Over the past several years, the total plastics production handled by the reprocessor has been decreasing. During the Sixties, as the resin producers became more sophisticated and their profit margins decreased, they improved their processes and generated less scrap, which reduced the volume of SP going to the reprocessor. Today the reprocessor industry is composed of 50 to 75 companies, most of which are small. Sales of secondary resins by this segment were only $150 million in 1970. As the profitability of reprocessing has diminished, the reprocessors have turned their business more toward the compounding and distribution of virgin resins (mainly offgrade).

## The Plastics Cycle

In addition to the segments of the plastics industry mentioned above, the plastics cycle through which all plastic articles pass includes the wholesaler/retailer and the consumer. Further, the consumer segment is made up not only of the householder and various industries, but also of such institutions as hospitals, restaurants, and airlines. All of these segments contribute NP to the disposer who collects and disposes of it in land fill, by incineration, and other methods.

As a plastic product is made, starting from the resin, it normally passes through manufacturing facilities that become progressively smaller in size and more widely dispersed geographically. The wholesaler/retailer and consumer segments are obviously concentrated according to population density.

Each segment in the plastics cycle has a role to play. The resin producers, which are the largest companies in the cycle, determine the chemistry of the plastic item. The converters and fabricators determine the structure of the plastic product--whether it will be a garment bag or an appliance part, for example. The manufacturer/packager is often the major decision-maker in determining the type and form of plastic item, because he is the one who instructs the fabricator or converter to make the product of his choice. Thus, if he is a packager he usually decides whether his product will be sold in plastic bottles or in a plastic pouch. He is keenly aware of the needs of the consumer, and he works closely with the fabricator and converter in setting specifications.

We defined the term "NP" as plastics of no value, but this is a time-dependent phenomenon. The consumer disposes of a plastic item only after a certain lapse of time, which is the service life of the product. For example, packaging, novelties, disposables, etc., have a short service life (less than 1 year). Other items, such as furniture, sporting goods, and luggage have estimated service lives of 6 to 10 years, and products such as instruments, hardware, and various machinery can serve for 11 to 20 years. It is those plastic items having a short service life that are the major source of NP in the disposal site today and, therefore, recycling of these should be promoted.

Packaging--a short service life product--is the major source of NP. The NP derived from packaging wastes generated by the five major thermoplastics accounted for 60 percent (weight) of the 6.5 billion pounds of all NP in the disposal area in 1970. Assuming that conditions and technology remain unchanged, we estimate that plastic packaging wastes will still dominate the disposal area in 1980 when they will be equivalent to 10 billion pounds or 54 percent of all NP. If the plastic beverage container becomes a reality, plastic packaging wastes could increase to 12 billion pounds by 1980, or almost three times the 1970 volume. This would represent about 59 percent of all NP in the disposal area.

The second major category of NP is that generated by each segment of the plastics cycle as the product is made--from monomer to consumer. We estimate that in 1970 approximately 1 billion pounds of NP was derived from this source alone. This represents 15 percent of the total NP in the disposal area derived from the five major thermoplastics. NP from this source will rise to 3 billion pounds by 1980, when it will account for 16 percent of the total NP.

Thus, these two categories of NP--packaging and industrial wastes--account for 75 percent of all NP in the disposal area. NP derived from other consumer products accounts for only a small fraction of the total. For example, the third major fraction of NP in the disposal area comes from discarded housewares; but this source is a distant third and represents only 6 percent of the total NP. Often these other wastes are an integral part of a non-plastic material and therefore are more difficult to recycle.

Of the five major thermoplastic wastes in the disposal area today, 70 percent is based on polyolefins: HDPE, LDPE, and polypropylene. PVC accounts for about 18 percent. Of the NP derived from spent packaging alone, 83 percent is polyolefins and 6 percent is PVC. We foresee little change in the chemical composition of NP generated by the five major thermoplastics during this decade.

Industrial wastes are generated primarily from the fabricating and converting processes. These account for about 57 percent of the industrial NP; the remainder comes from resin production, packaging, assembling, and distributing. LDPE and PVC predominate in these wastes; they account for 34 and 32 percent of the total, respectively. The high concentration of PVC in these wastes arises from its more difficult processing characteristics. This distribution of various plastics will probably not change during this decade if the present conditions continue.

## Scrap and Nuisance Plastics: Applications and Markets

In addition to some of the technical impediments to recycling already mentioned, another significant consideration is the possible presence of additives in the scrap plastic. Depending upon the application, the additives may be inappropriate and the scrap then becomes NP. For example, if a cadmium-based pigment is present in the scrap, this scrap cannot be recycled readily for a toy application, because the pigment is poisonous. Furthermore, all plastics that come in contact with food require FDA-approved additives; and scrap containing additives that are designed for one fabrication process occasionally interfere with the use of this scrap in another fabrication process. In addition, certain inks can also hinder recycling because they promote degradation of the plastic material during the reheating process.

As a general rule, scrap plastic has to be used in an end application having broader specification requirements than the product yielding the scrap. The fabrication of bottles, film of high quality, and certain coatings requires resin with tightly controlled specifications. In contrast, many plastic products made by molding or extrusion, whether they are housewares or pipe, use resin having a relatively broader specification range. Thus, scrap from plastic bottles, though difficult to recycle as bottles, can be used for pipe, siding, and a variety of structural products.

Scrap is being used to make a number of products today, and we believe that if more secondary resin is made available at a sufficiently low price, new applications will develop. Flexible PVC, for example, can be used to manufacture such end items as hose, weather stripping, certain coatings, and a number of molded articles. Much of the polyolefin scrap today is used to manufacture duct work in automobiles, and the use of scrap plastic as filler in foamed plastic products is a developing application. New applications on the horizon include the use of scrap plastics in concrete to improve the strength of concrete and its ease of fabrication. One company has developed a coating for fiber drums based on scrap from polyethylene-coated fiber board that is available from both converters and fabricators. This coated scrap could also be used in novel molding processes to make construction articles. Some longer-term applications might possibly include the use of scrap plastic to absorb oil spills or to produce artificial snow.

One company today is considering constructing a plant that will be capable of recycling scrap that is available in large quantities from the manufacture of PVC-coated fabrics used extensively in upholstery. Their process involves the solvent extraction of the PVC, leaving the fabric backing. Both products can then be sold for recycling.

A major market for scrap plastic is plastic pipe. The pipe, fittings, and conduit market used 380 million pounds of plastics in 1970. About 50 million pounds of offgrade polyethylene were used in 1970 to make utility pipe for open drainage, drain tile, and other non-pressure applications. The use of polyethylene in drain tile is a new application. This market could use as much as 200 to 300 million pounds of polyethylene per year in the coming years. Certain high-quality high-density polyethylene scrap could be used in this product area. Low-head irrigation pipe is another market where secondary resins could penetrate. It is at least a 40-million pound per year market. Perhaps the largest market, which has barely been penetrated, is the manufacture of sub-soil irrigation pipe from secondary resins. This pipe can be used to irrigate arid land and is already being used to water lawns.

Another potentially large future market for scrap plastics is pallets. In 1970, about 10 million pounds of HDPE were used in this application, but this figure could rise to as much as 300 million pounds per year by 1980.

Many of these applications need further development before they can be considered commercial. A few resin companies are carrying out research to explore new applications, and we believe this is a fruitful area for new research--one that warrants Government funding.

Plastics are materials that can be recycled to produce non-plastic products (we have chosen to call this process tertiary recycling). For example, pyrolysis of scrap polyethylene converts it into waxes, greases, and oils. Most plastics can be pyrolyzed, and by varying process conditions, the products obtained can be either solids, waxes, liquids, or gases. This approach also warrants more research. The economics of these processes are not yet very well known, but they can be crucial in developing a viable recycling process. Tertiary recycling is a more severe downgrading of the plastic scrap than secondary recycling which involves the recycling of scrap from one product to make another plastic product. The later approach yields a product of higher value than that produced by pyrolysis.

The highest value is obtained by reusing the plastic product, or by recycling the scrap back into its original product form (primary recycling). The best example today is the returnable polyethylene milk container. About 8 million bottles of this type were used in the U.S. in 1970 for 288 million fillings. This represents the removal of 65 million pounds of scrap polyethylene per year from the disposal area.

As another approach to the reusable plastic container, a new company was formed in 1970 that de-inks plastic containers for packagers and labelers who incorrectly labeled containers. The de-inking process can be used perhaps to salvage many spent plastic containers discarded either by the manufacturer or the consumer. Obviously, if a reuse is a possibility, it should be promoted, for a fabricated container is usually worth about three times the cost of the raw material.

## Tactics and Strategies for Recycling Plastics

In developing strategies and ranking alternative solutions to the problems of recycling plastics, we used the following criteria: (1) minimize environmental damage, which is essentially subjective and not easily measured; (2) maximize pound-volume of "troublesome" nuisance plastics recycled and/or reused as a percentage of total plastics production (troublesome NP has low bulk density and/or is a problem to incinerate); (3) minimize pound-volume yield of troublesome nuisance plastics as a percentage of total plastics production; (4) minimize the "social" costs of achieving objectives 1, 2, and 3; (5) minimize economic disruption of industry; (6) minimize disposal costs; and (7) maximize the recyclability of plastics. The primary objective is to reduce environmental damage, and an effective way to do this is to recycle discarded plastic products. The interest in minimizing disposal costs follows from the conclusion that all plastics are not recyclable; therefore, those remaining should be disposed of with minimum cost to society and the environment.

In developing alternate strategies, we have assumed that the cost to society of failing to clean up the environment is greater than the clean-up costs. In other words, no matter how much it would cost to recycle or dispose of NP with minimal environmental damage, from society's view, the cost of doing nothing is, say, one dollar greater. Clearly, this assumption must be re-evaluated when the costs are more accurately known.

Another important consideration in developing our recommendations concerns the systematic interdependencies in both our ecological and economic systems. These interdependencies, therefore, make any piecemeal action inefficient and potentially harmful, because discouraging the use of one substance (e.g., virgin plastics) may merely transfer pollution from one source to another. This need implies that certain strategies developed for promoting recycling of plastic wastes must include not only plastics but glass, metal, paper, etc. Therefore, in considering various strategies, we noted where they had to apply to all materials and where they could be applied to plastics alone. However, because this study was restricted to plastics, we only analyzed the impact of our recommendations on the plastics industry.

To promote recycling effectively requires partial control or conditioning of the production and consumption of these materials, which can be accomplished either by regulation or by economic incentives or disincentives. Because the essence of our system is consumer sovereignty and the belief that resource allocation (production and consumption decisions) can best be guided by a price mechanism, we believe that regulation by legislation to promote recycling is inconsistent with this philosophy of a free-market economy. Consequently, the strategies discussed below are built primarily on economic incentives and disincentives rather than regulations, because the major impediment to recycling plastics today is the economic one.

Some of the schemes, while primarily intended to influence production-consumption choices, will also yield resources. We recommend that revenues generated by any taxing schemes be considered as part of the Federal Government's general tax revenues. In general, we do not favor the trust-fund theory of taxation and revenue use. While this approach may be beneficial in the short run; in the long run it might invite the sub-optimization of public funds. Generally, trust funds are not satisfactory because they "lock-up" funds over an extended time.

We considered the following schemes of selective taxation and incentive payments: (1) a tax on virgin materials; (2) an incentive payment to promote the use of secondary materials; (3) a tax on all non-recycled products, which is applied to all plastic products that are not easily recyclable; (4) a rebatable tax on all products that are recyclable.

Tax on Virgin Materials. This tax is designed to directly widen the gap between virgin and secondary materials. It could be levied on the monomer producer who would collect it from the resin producer. Effective compliance would be expected, and administrative costs would be minimal. This tax would be levied on all resins on a volume rather than a weight basis. However, it could not be levied on plastics alone, because taxes on virgin materials should not discriminate against one material, unless the material is demonstrably more damaging to the environment than others.

Though this tax can provide the economic incentive to use secondary resins alone, this tax will not be very effective, because it does not assure an adequate supply of quality secondary material. Furthermore, reprocessing costs would not be reduced, and the raw material, namely scrap plastic, would become more costly. Therefore, only a small portion of the NP would be converted to secondary resin. Marginal NP from the industrial sector would remain untouched. Perhaps about 20 percent of the industrial NP (about 200 million pounds) would be converted to secondary resin, if this were the only tactic.

If clean consumer scrap were made available at a low price by some economic scheme, this tax could promote its conversion to secondary resin. As much as 1.5 billion pounds of this scrap are potentially available. But again, auxiliary tactics would be required.

This tax would adversely affect our balance of trade because the price of U.S. goods would be inflated. Conversely, the demand for foreign goods would increase in the U.S., and imports would be encouraged. And, because this tactic must be applied to all materials, this effect could be very pervasive and would tend to reduce our gross national product and increase unemployment.

Incentive Payment to Promote Recycling. The primary objective of this tactic is to increase the demand for secondary resin. This tactic need not be employed across-the-board to all material categories, although we recommend that all materials be considered.

The incentive payment would be most effective if offered to the scrap generator, who would show by his invoices that scrap was sold to a reprocessor or an outside fabricator. The scrap generator would then list the sale on his Federal Income Tax Form and request payment. This action would simultaneously increase the supply of secondary resin and the demand. It would motivate the scrap generator to segregate, store, and transport much of the scrap plastic that he now considers marginal to a reprocessing facility.

This system of awards should promote the recycling of industrial scrap plastic that is relatively clean and is generated in isolated locations. Although industrial NP amounts to about 1 billion pounds per year today, perhaps no more than 75 percent or 750 million pounds is actually usable for recycling because of contamination. This NP is in addition to the 1 billion pounds of scrap plastic that is presently being reprocessed annually.

This incentive system may also motivate the formation of centers for the separation and collection of consumer NP, especially that from large institutional and commercial consumers. These centers also could receive this incentive payment. Although the volume of consumer NP available is much greater than the volume of industrial NP, most would be difficult to retrieve based on current technology, either because the NP is part of a composite or a multi-plastic product, or it is not economically collectable. Potentially, only NP derived from spent packaging can be recycled. However, because recycling requires collectability and monoplastic materials, at this time no more than 1.5 billion pounds of this type of consumer NP are available, which is equivalent to all monoplastic rigid packaging.

Realistically, however, the most collectable items are plastic bottles. Over 600 million pounds of plastics were used to make bottles in 1970, and this market is expected to increase to 1600 million pounds by 1980 (exclusive of the new acrylonitrile plastics on the horizon). Of the "big five" plastics used to fabricate bottles in 1970, over 80 percent (or 500 million pounds) was HDPE.

HDPE is used to package such major products as milk, bleach, detergents, and other liquid laundry detergents. Packaging for these products accounted for 400 million of the 500 million pounds of HDPE used in 1970; and only two major grades were used. Thus, the successful collection of these bottles could provide a "clean" stream of one plastic. Although effective collection of these spent containers from the consumer would remove only 7 to 8 weight percent of the total NP, it is the volume occupied by this NP that is more significant. These bottles, if uncrushed, represent about 30 percent of the volume of plastic wastes. As a maximum, we estimate that all usable consumer NP (primarily rigid packaging wastes) amounts to no more than 750 million pounds per year.

Accordingly, the total potential volume of recyclable NP from both the household consumer and industry is about 1.5 billion pounds per year. This could increase to about 4 billion pounds per year by 1980, and, if consumer recycling programs are successful, an even larger proportion of packaging wastes may be recovered and reprocessed.

Under this award system, fabricators would purchase more secondary resin, because the supply would be assured and available at relatively low prices. However, if the price of the secondary resin is lowered because of the substantial increase in the supply of scrap, the demand may still not increase if the market is inadequate. However, we believe that new markets will automatically arise with an appropriate incentive payment. Secondary resins will probably replace the virgin materials in those applications that do <u>not</u> require resins with very narrow specifications; hopefully, secondary resins will also enter brand new markets, where they will not be competing with virgin plastics but with non-plastic materials such as wood, cement, etc.

This strategy could be used alone to promote recycling, for it does not necessarily require auxiliary tactics. However, because an incentive payment requires a net payout by the Government, a desirable auxiliary tactic would be one that generates funds such as the tax on virgin materials or the tax on non-recyclables described below. These funds, then, could be used to provide the awards to the scrap generator.

Tax on Non-Recycled Products. The primary objective of this tax is to promote a demand for recyclable products and, therefore, the supply of useful consumer scrap plastic. This scheme assumes that an effective collection and separation system exists for plastics. If the product cannot be made available in an easily recyclable form, then the secondary objective of this tactic is to reduce the disposal and social costs of non-recyclable products; ideally, this tax should be computed to reflect these costs. Furthermore, this tax, like the tax on virgin materials, would have to be levied on products made from all materials to avoid adverse selection, as discussed previously.

An example of a "finely-tuned" tax is one that would reflect the disposability characteristics of a discarded product, such as (1) service life; (2) chemical composition, which indicates behavior in an incinerator or a land fill; (3) volume occupied by the discarded product in the disposal area; (4) compressibility, which reflects the ease with which the volume of the spent product is reduced by the various intermediate treatment processes and/or the final disposal process.

This tax would preferably be computed by using the service-life property as a factor for multiplying the sum of the three other properties. Thus, the tax could be designed so that items with relatively long service lives would bear no tax. This tax would be computed on a weight basis, but with a density correction factor that would be used to equalize the tax on materials of different density.

The characteristics of a product that this tax reflects have been designed into the product before it reaches the manufacturer/packager segment of the plastics cycle. But, because the manufacturer-packager is the most significant decision-maker in selecting the package, we believe that the tax should be imposed on him.

This tactic could promote recycling only if an effective collection and separation system exists for spent plastic products, because the consumer would select the less expensive recyclable product that would not bear this tax. However, most of the potentially recyclable products are voluminous rigid containers that can be viewed as relatively costly to dispose of. Therefore, this tactic requires an auxiliary tactic such as the rebatable tax described below to insure that the recyclable plastic products are indeed collected and separated; otherwise all plastic products, whether potentially recyclable or not, should bear a tax.

This scheme will also require a thorough analysis of the disposability characteristics of spent products (primarily packaging) to establish various taxation levels. Furthermore, because this program is somewhat more complex than those mentioned above, administrative expenses may be an important factor when one compares the costs versus the benefits of this tactic.

Rebatable Tax. The objective of this tax is to directly promote recycling by providing a supply of scrap plastic primarily from the consumer. This tax is essentially a tax on plastic packaging materials, for these are the most easily collected and recycled. The effectiveness of this tax obviously depends on the availability of a collection and separation system.

In this scheme, the consumer would receive an award payment to pay for his costs of sorting, storing, and, if necessary, transporting spent containers to collection centers. These containers would bear a rebatable tax. Interception via a collection center is only one approach--collection from the home is not ruled out.

The rebatable tax would be levied according to the size of the container--the larger the container, the higher the tax. And, generally, the rebatable tax on a package would be higher than the tax on the non-recycled package. However, different rigid containers are often used to package the same item, such as milk, water, etc. If one of these containers is recyclable, an equivalent tax would be levied on all rigid containers used to package this item. This would provide a powerful incentive for promoting the use of recyclable packaging. This tax would be imposed on the wholesaler/retailer and collected by the manufacturer/packager who would list the tax as a separate item on his sales invoices.

To avoid the strong objections of the retailer, we suggest that collection centers to collect items bearing the rebatable tax be set up at convenient locations for the consumer outside the retailer's store. These centers could be operated by a local government or by an appropriate private agency operating under government control. The bounty offered for the selected discarded container could be equal to, less than, or more than, its rebatable tax, depending on factors such as the market price for the spent material, the social costs involved in its disposal, etc.

This tactic, if successful, could generate about 400 million pounds of scrap HDPE from the consumer per year, based on 1970 consumption statistics, and perhaps as much as 1100 million pounds of scrap HDPE per year by 1980. This still represents only about 5 pounds of plastic per capita per year. These statistics assume that the consumer would be asked to return only the plastic bottles used for the major commodities, namely milk, bleach, and detergents.

But the administrative costs of this program are no doubt the highest of any program discussed so far. And the need to develop a working arrangement between the Federal and local government groups further complicates the successful operation of the program.

Other Tactics. In addition to these taxation concepts, we recommend that the Federal Government review political impediments to recycling imposed by Federal, state, and local agencies that restrict the use of secondary materials, and, in particular, purchasing specifications. We also recommend that the Government, together with the plastics industry, develop standards for secondary resins similar to those for the virgin products and set up an inventory of all sources of plastic scrap, describing availability, physical and chemical form, etc., as a resource for fabricators interested in purchasing secondary material.

The tax revenues that would be realized by some of the schemes outlined above could well be used to contribute to the general improvement of the current systems of disposing of NP. And to meet the economic impediment head on, the Government could reduce reprocessing costs directly by providing easy financial conditions for extending and operating a reprocessing business. Thus, the Government could provide tax credits, special depreciation allowances, low-interest loans, and similar incentives.

A very worthwhile use of some of the tax revenues would be to promote research and development specifically directed at making reprocessing technically and economically more attractive. Furthermore, research programs directed at developing new applications for scrap materials obviously will be very helpful to the reprocessor and should promote recycling.

Final Recommendations. The key programs that will reverse the trend and promote the recycling of plastics will require legislation. We believe that an incentive payment as discussed above can go a long way toward increasing recycling at a minimal cost. This program can be initiated for plastics alone, if that is desirable, but most importantly, this program does not require auxiliary or supporting legislatve programs to operate effectively.

Providing easy financing for the reprocessor is similarly a program that does not require other legislative programs; but this tactic will not be as effective as the incentive payment in promoting recycling. However, its administrative costs would be low.

All of the other taxation schemes described above require a number of auxiliary tactics to be effective. And the rebatable tax and the tax on non-recyclables must be levied together to achieve the desired effect. These two tax schemes also have the further disadvantage of requiring extensive preliminary analysis; furthermore, once instituted, they will probably be expensive programs to administer, as compared to the others.

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