



---

**TABLE OF CONTENTS**

Introduction	1	How Is Film Waste Managed?	10
What Are Plastic Films?	2	Waste Minimization/Source Reduction	10
How Much Plastic Film Is There?	2	Quantifying Plastic Film Waste	11
In What Applications Is Film Used?	3	Landfilling	13
Food Packaging	3	Combustion	13
Nonfood Packaging	4	Recycling	15
Other Packaging	4	What Does Film Recycling Involve?	17
Nonpackaging Applications	4	Film Recycling Processes	17
What Resins Are Used to Make Film?	5	Film Recycling Equipment	18
LDPE/LLDPE	5	Challenges in Film Recycling	20
HDPE	5	Examples of Where Film Recycling Makes Sense	28
PP	6	Additional Sources of Information	28
PVC	6		
PET	6		
Other Resins	6		
The Benefits of Plastic Film	7		
Source Reduction	7		
Cost	7		
Functionality	8		
Versatility	9		

---

## INTRODUCTION

In today's competitive marketplace, manufacturers of products and packages are under increasing pressure to satisfy varied—and often conflicting—demands, such as lowering costs, improving performance and enhancing environmental attributes. Within this arena, the material that a manufacturer chooses to use in its products and packages can affect its ability to remain competitive.

Plastic film, in many instances, has allowed manufacturers to meet varied marketplace demands by enabling them to do more with less. Unfortunately, information on this broad category of materials is lacking. With this white paper, the American Plastics Council (APC) hopes to meet this need by providing

technical experts and laypersons with a better understanding of what film is, how it is used, how it contributes to resource conservation, and how it can help manufacturers respond to the changing marketplace.

In addition, since there appears to be a growing interest in recycling film, the report discusses the pros and cons of recovering it for recycling. A series of sidebars highlighting effective film recycling efforts has been included to help illustrate the circumstances under which plastic film recycling may make sense. Equally important, this white paper discusses the role that plastic film plays in reducing the amount of waste generated in the first place.

## WHAT ARE PLASTIC FILMS?

Often when people talk about plastic films—which technically are defined as plastic sold in thicknesses of up to 10 mils<sup>1</sup>—they treat them as one type of material, grouping all flexible plastic packaging into a single category. What they do not realize is that plastic films compose a broad category of materials that can be relatively simple or complex depending on the demands of a particular product or package.

Like plastic bottles and containers, film can be made with different resins, each of which has a unique combination of properties that makes it ideal for certain applications. For example, low density polyethylene (LDPE) film acts as a gas barrier, which is necessary

for packaging such things as chicken, which would quickly spoil if exposed to oxygen. Polyvinyl chloride (PVC) film, on the other hand, is gas permeable and necessary for packaging such things as red meat, which require a small amount of oxygen inside the package in order to remain fresh.

Plastic film also can be clear or colored, printed or plain, single- or multilayered and combined with other materials such as aluminum and paper. Thus, the only thing that all plastic film really has in common is that it is flexible in nature, as used in grocery bags, as opposed to rigid, as used in soft drink bottles and butter tubs.

## HOW MUCH PLASTIC FILM IS THERE?

While it is hard to define plastic film, it is even more difficult to quantify how much of it is used in packaging and nonpackaging applications. That is primarily because of the way that data are reported. For example, trade organizations and major publications rarely separate film from other types of plastic (such as rigid packages), and if they do, the level of detail available on film usage—such as breakdowns by use in food and nonfood packaging—is not consistent across resin types. For that reason, obtaining accurate and complete data on film is a rather arduous task.

Perhaps the best data currently available on film generation are compiled by The Society of the Plastics Industry, Inc. (SPI), which shows that 10,375 million pounds of resin were sold domestically into film applications in 1994 (see Exhibit 1). Interestingly, the polyethylene (PE) family accounts for approximately 86 percent of the resin sold and reported on in that year: Linear low density polyethylene (LLDPE) composed 36.6 percent of the resin sold into film applications, LDPE accounted for 34.8 percent and high density polyethylene (HDPE) accounted for 15 percent. The remaining 14 percent of plastic film was made from polypropylene (PP) at 8.9 percent, PVC at 3.7 percent and nylon at 1 percent.

Even these data, however, are problematic for several reasons. First, figures on film in certain resin categories are reported in combination with other forms of plastic. For example, SPI data include only one

Resin	Pounds	Percent
LLDPE	3,801	36.6
LDPE	3,607	34.8
HDPE	1,560	15.0
PP	927	8.9
PVC	387	3.7
Nylon	93	1.0
Total	10,375	100.0

SOURCE: SPI Facts & Figures, 1995

number for both PVC film and sheet. (PVC sheet, which is thicker than PVC film, is semirigid and can be thermoformed into such packages as blister packs, cookie and cracker trays and other types of trays and cartons for food and nonfood applications.) Similarly, the data show only one number for both nylon film and coating.

Second, SPI data do not include information on the amount of polyester (PET) or ethylene vinyl acetate (EVA) sold into film applications, even though they are commonly used to make film. The only data available on these two resins comes from Modern Plastics,

which found that in 1995, 680 million pounds of PET were sold into general film applications, 102 million pounds of PET were sold into magnetic recording film applications and 725 million pounds of EVA were sold into film applications. Because Modern Plastics derives its figures differently from SPI, the two should not be used together to make calculations about total film generation. The Modern Plastics data do, however, give some idea of the magnitude of use of these resins to make film.

Third, the level of data available on different film resins varies considerably. For example, as you will see later in this report, only polyethylene films are broken down into food packaging, nonfood packaging, other packaging and nonpackaging categories, even though we know that other resins are used in these applications. It is not clear why SPI and Modern Plastics have chosen to do this, but nonetheless, data on other film

resins used in these applications simply are not available.

Finally, the data collected on film generation are problematic because neither SPI nor Modern Plastics includes data on the use of polyvinylidene chloride (PVDC), ethylene vinyl alcohol (EVOH) or polystyrene (PS). All of these resins can be used to make film, although they tend to be used in very small quantities.

Therefore, while the data available in this report are helpful in understanding the general distribution of film by resin type, the lack of detail and consistency in current reporting mechanisms makes it difficult to develop a fully accurate picture of how much of each resin is used in film applications and how much film is generated overall.

---

## IN WHAT APPLICATIONS ARE FILM USED?

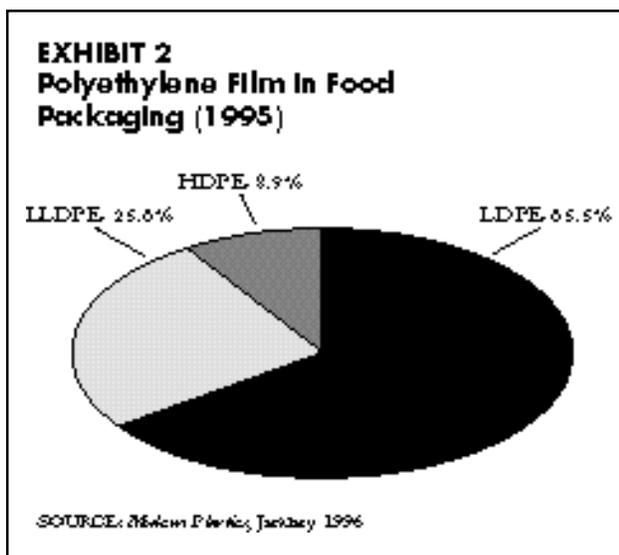
Another reason why it is somewhat difficult to get a grasp on plastic film is because it is used in such a wide range of products and packages. Typically, its usage is divided into two general categories—packaging and nonpackaging—that can also be broken down into smaller components. For example, there are three types of packaging applications in which film is used: food, nonfood and other. It is important to keep in mind that within each of these categories, plastic film can vary by resin and color; it also may be made of one layer of plastic or as many as ten layers depending on the complexity of the package. In addition, other materials—such as aluminum or paper—may be used in combination with plastic film in order to impart special properties. Therefore, even the following categories of film are themselves made up of many diverse types of film.

### Food Packaging

Food packaging film is used in such things as in-store bags for produce (such as apples and potatoes); all nonfrozen baked goods (such as rolls and breads); bakery bread and bun bags; tray covers for institutional deliveries of bakery products; bags-in-a-box (film used to contain fluid in a supportive box, such as boxed wine); boil-in-bags (film used to contain food prepared by keeping it in the package and placing it in boiling water); candy and confection bags and

wrappers; carton liners (for such products as cake mixes); and meat, poultry and seafood wraps (such as hot dog and bacon film).

As mentioned in the section on film generation, the only data available on the use of film in food packaging applications are restricted to the polyethylene family, despite the fact that other resins are used in food packaging as well.

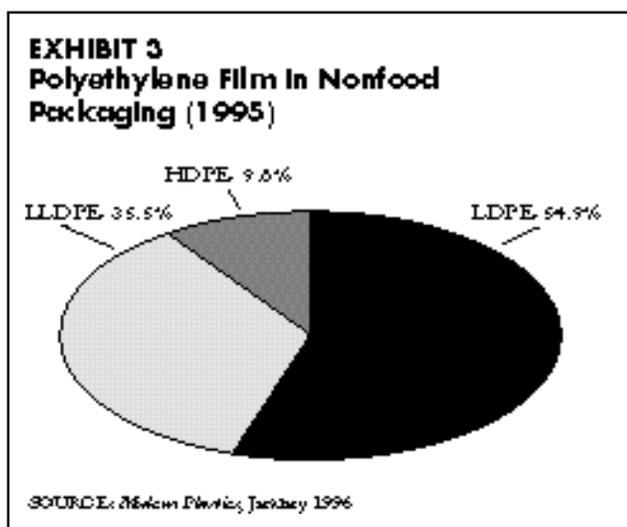


It is worth pointing out that LDPE is the polyethylene resin used most often in food packaging; it accounts for 65.5 percent of the total, with LLDPE making up 25.6 percent and HDPE making up 8.9 percent (see Exhibit 2).

### Nonfood Packaging

Nonfood packaging film refers to such things as industrial liners (film used to line supported structures such as gaylord boxes, frozen pork box liners and liners for shipments of nuts and bolts), shipping sacks (film used to protect and/or contain contents such as bark and mulch bags), bubble packing, envelopes, multiwall sack liners, overwrap, and rack and counter bags. Again, data on film used in nonfood packaging applications are confined to the polyethylene family.

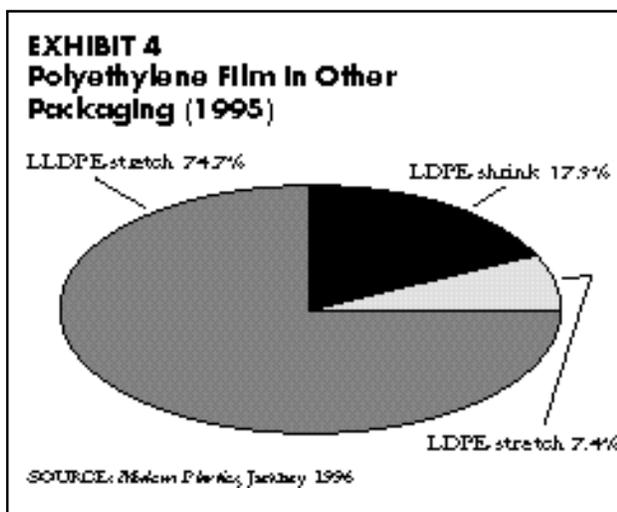
As Exhibit 3 shows, LDPE is the polyethylene resin used most frequently in nonfood packaging applications. It composes 54.9 percent of the polyethylene used in nonfood packaging, whereas LLDPE composes 35.5 percent and HDPE composes 9.6 percent.



### Other Packaging

The other types of packaging in which film is found are stretch and shrink wrap. Stretch wrap is a strong, highly flexible film that can be stretched to take the shape of a product or products. It is used in a variety of applications ranging from overwrapping fresh meats to securing shipping cartons to pallets. Stretch wrap usually is made of co-extruded LLDPE and LDPE, although it can be made from individual plastic resins, such as LLDPE, LDPE and PVC.

Shrink wrap, on the other hand, is a plastic film that is



applied loosely around products, sealed by heating the seams and shrunk through a heating process to take the shape of the products. In shipping, it can be used to bind multiple packages of less than pallet size together (such as five 20-ounce cans of beans or three juice boxes) or used over an entire pallet of packages. In these applications, shrink wrap typically is made of LDPE, although it can be made from other resins as well, such as LLDPE and PP. In addition to shipping applications, shrink wrap also can be used for bundling purposes, such as bundling magazines and papers, and it can be used to protect and display such products as albums and compact disks.

There are several ways to tell stretch wrap and shrink wrap apart: stretch wrap usually feels somewhat tacky to the touch and is very flexible, whereas shrink wrap may be more brittle (or crinkly) to the touch and does not stretch when pulled. In addition, stretch wrap usually is wrapped around products, whereas shrink wrap will enclose the product (that is, have a top and bottom cover), which makes it an attractive choice for shipping products in extreme weather conditions or for products that need extra protection.

Data compiled by Modern Plastics show that a total of 1,074 million pounds of polyethylene film were used in "other" packaging applications in 1995. (Again, data are not available for nonpolyethylene resins or for HDPE.) As Exhibit 4 shows, LLDPE is used most often in stretch wrap applications (at 802 million pounds) and LDPE is used most often in shrink wrap applications (at 192 million pounds).

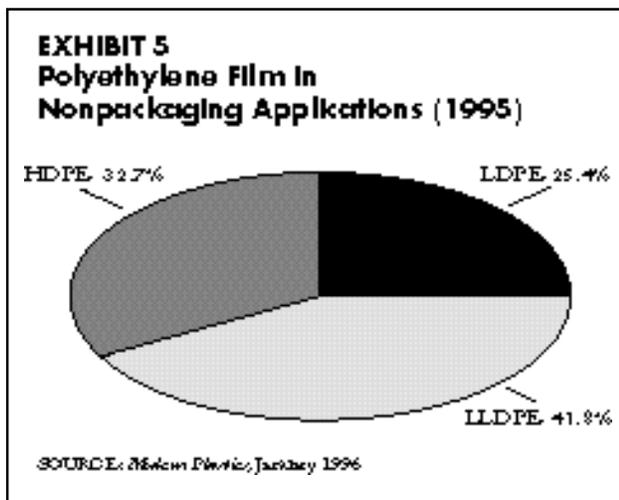
### Nonpackaging Applications

Of course, a great deal of film also is found in a category the industry refers to as nonpackaging

applications. For example, it is commonly used to produce grocery, T-shirt and trash bags; can liners; agricultural film (such as greenhouse, fumigation and mulch films, haysleeve covers and silage bags); construction film (such as vapor barriers in walls, moisture barriers under concrete, paint drop cloths and drapes); medical and health care film (such as garbage and hazardous material bags, I.V. bags and sterile wrap); garment bags; self-service bags; household wrap; and as a component of disposable diapers.

According to figures from Modern Plastics, approximately 3,730 million pounds of polyethylene film were used in nonpackaging applications in 1995. Exhibit 5 shows how that film was distributed by polyethylene resin type.

It is important to remember that the figures presented in this section focus only on polyethylene films because data are collected in this manner only for members of the polyethylene family. That does not mean, however, that only polyethylene is used in these applications. For example, in the nonpackaging cate-



gory, PP films are used in such things as diapers and in the packaging category, polyester and polypropylene films are used in sterilization wrap.

---

## WHAT RESINS ARE USED TO MAKE FILM?

Like bottles and containers, plastic film can be made with a variety of plastic resins. Following is an explanation of some of the different resins with which film is made, a description of their properties and some of the applications in which they are commonly used.

### LDPE/LLDPE

These two polyethylene resins often are talked about as if they are one because they have similar properties—both have good clarity, are good moisture barriers and fair gas barriers, can be heat sealed and are strong and highly flexible. They both are also used in similar applications, including but not limited to stretch wrap; shrink wrap; bags for produce, bakery goods, candy and ice; bags-in-a-box; boil-in-bags; carton liners; bubble packaging; envelope film; industrial liners; overwrap; shipping sacks; textile bags; mattress bags; grocery sacks; garment bags; trash and can liners; and agricultural and construction film.

They do, however, have some differences that make them preferable for different applications. For example, LDPE is often selected for its high clarity, ease of processing and high gloss. LLDPE, on the other hand, is selected for its tensile and impact strength

(i.e., its toughness) as well as its heat sealability. LDPE tends to be used more often in things like food and nonfood packaging and shrink wrap; LLDPE is used more often in trash bags and stretch wrap.

### HDPE

Because it is part of the polyethylene family, HDPE film is found in many of the same applications as LDPE and LLDPE. For example, HDPE film is used in bakery bags, carton and box liners, cereal and cake mix bags, shipping sacks, industrial liners, retail bags, grocery sacks, T-shirt bags, trash bags and liners, agricultural film, construction film and envelope material (such as Tyvek), as well as many other products and packages. In recent years, it has made inroads into the film market mostly because of its down-gauging properties, which allow manufacturers to use less material (i.e., source reduction) to make a package that can deliver an equal amount of product. HDPE also tends to be stiffer than other polyethylene films, which is an important characteristic for packages that need to maintain their shape. In addition, HDPE is strong and puncture resistant, has good moisture barrier properties and is resistant to grease and oils.

## PP

PP film has excellent moisture barrier characteristics, good clarity, high gloss and good tensile strength. The resin also has a high melting point, which makes it desirable in packages that require sterilization at high temperatures. PP film commonly is used to package such things as cigarettes, candy, snack foods, bakery products, cheese and sanitary goods. It also can be found in shrink wrap, tape, tobacco wrap, diaper coverstock and the sterile wrap used in hospitals and other medical care facilities. Because PP has only average gas barrier properties, it often is used in combination with such things as a PVDC coating or acrylic, which provide additional barrier properties.

## PVC

PVC film can be found in stretch wrap for industrial and pallet wrap (although in very small amounts), shrink wrap (again in very small amounts), some bags and liners, adhesive tape, labels, blood bags and I.V. bags. It also is used exclusively to package fresh red meats. That is because it is semipermeable, which, as mentioned earlier, means that just enough oxygen can pass through the film to keep the meat fresh and maintain its bright red color. PVC film also is a good barrier to oil and grease, is puncture resistant and has good cling and excellent clarity.

## PET

PET film is mostly found in nonfood, nonpackaging applications, such as photographic film, x-ray film and magnetic audio and video recording film. It also is used in solar control film, overheads and ink jet films and in general laminations for things like business cards and luggage tags. Its primary packaging uses, however, are in metallized packages, such as those for potato chips and pretzels, as well as in microwave packaging, brick packs and medical packaging (such as sterile wrap and lidding material on pull-away packs). It also can be found in tobacco wrap, cigarette wrap and labels. PET is used in these and other applications because it has good mechanical properties—such as toughness and stiffness—and good thermal properties, which means it can withstand higher processing temperatures than some other resins. PET also can be clear or pigmented, which is advantageous in certain applications. (For a more comprehensive list of film applications by resin type, see Exhibit 12.)

## Other Resins

There also are several other film resins that are used in

much smaller quantities but impart special properties to a package.

PVDC has excellent moisture and gas barrier properties and is resistant to grease and oil, which makes it ideal for household wrap. (Its trade name is Saran™.) It also is commonly laminated or used as a coating with other materials (like PP) to impart added barrier properties.

EVOH is another film with excellent gas barrier properties, but it loses those properties when exposed to moisture. For that reason, it is commonly used in multilayer, co-extruded packages along with films, like PE, that have good moisture barrier properties. One place where EVOH typically is used is in modified atmosphere packaging where a special atmosphere is needed inside the package to help preserve the product. One example is packaging for fresh pastas, which require a high nitrogen, high carbon dioxide atmosphere in order to stay fresh and extend their cooler life. EVOH may be selected for this package because it can keep the nitrogen and carbon dioxide inside the package and oxygen outside. (PVDC may be used in similar applications.)

Nylon, like PP, has a relatively high melting point, which makes it ideal for use in conventional and microwave cooking applications. It also has good oxygen barrier properties, which make it ideal for use with other materials (like paper) that do not have good gas resistance. Nylon is said to be making inroads into cheese packaging because it does not allow oxygen into the package (which would spoil the cheese) but does allow carbon dioxide out (which, if trapped inside the package, would cause it to balloon). Nylon also is easy to process, which may give it an advantage over other specialty film resins.

EVA is used in some film applications. It has excellent adhesion, is inert and has good flex crack resistance and good heat sealing properties. Typically, this resin is not used alone but in combination with other film resins (like PE). For example, many bag-in-box applications (like boxed wine, some juices and soft drink syrups) are made of an LDPE/EVA copolymer. EVA also is good for packaging such things as meat, poultry and ice.<sup>2</sup>

Despite the fact that the data and information in this and the previous section (on film applications) are not ideally complete or comprehensive, it does demonstrate that plastic film is a complex family of materials, which has ramifications when evaluating film use and different waste management options.

THE BENEFITS OF PLASTIC FILM

The use of plastic film has grown steadily over time. According to data compiled by SPI, only 8,690 million pounds of plastic were used to manufacture film in 1990; by 1994, that number had increased nearly 20 percent, to 10,375 million pounds. (See Exhibit 6.) A brief discussion of some of the benefits of using plastic film, all of which have contributed to its recent growth in packaging applications, follows.

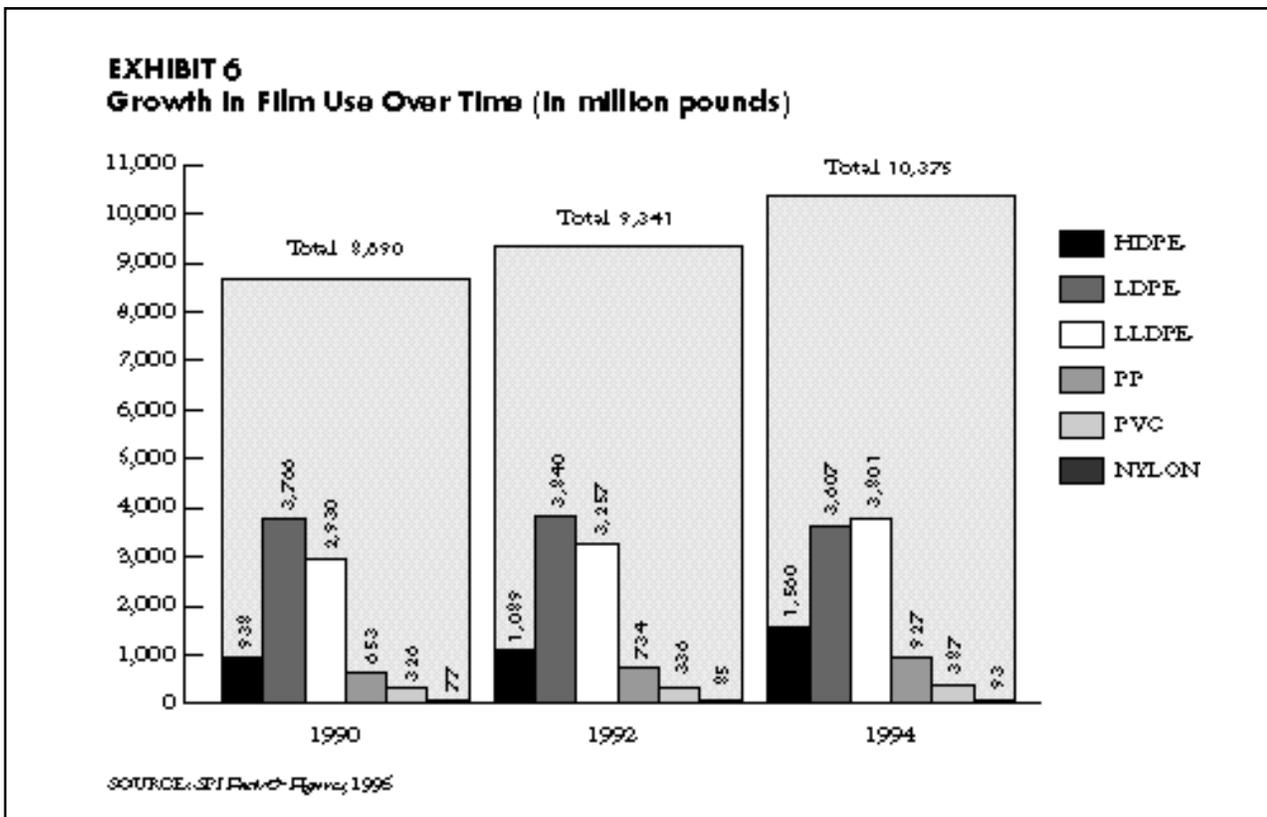
Source Reduction

Perhaps one of the biggest and most overlooked benefits of plastic film is its ability to substantially reduce the amount of material needed to make a product or package. How does it do that? Plastic has a high strength to weight ratio, which means that manufacturers can use less material when making a product or package. For example, in rigid packaging, a 16-ounce soft drink container can be made with only 30 grams of plastic whereas the same size container would require 200 grams of glass.<sup>3</sup> That means that substantially less packaging is needed to produce a package when a manufacturer uses plastic instead of glass.

Plastic film, however, has an even higher strength to weight ratio than rigid plastic, which means that manufacturers need even less material to make a package. For example, a plastic film pouch used to deliver concentrated fabric softener is 85 percent lower in weight and volume than a comparable plastic bottle, yet it delivers the same quantity of softener to the consumer.<sup>4</sup> The material minimization benefits that plastic film provides are among the reasons it has become a popular choice for packaging. In addition, if a package requires less material on the front end, it also creates less waste on the back end (i.e., waste minimization), which also makes plastic film desirable to manufacturers. (For more information on source reduction and waste minimization, see page 10.)

Cost

Plastic film's high strength to weight ratio also plays a significant role in a manufacturer's bottom line. Because very little plastic film is needed to produce a highly functioning flexible package (thicknesses generally range between .0005 and .003 inches), the



manufacturer has to purchase less material for the package, which translates into lower costs.

Using flexible packaging also can reduce costs in other ways. It takes less energy to produce; it takes up less space in stores and in production facilities; its light weight helps reduce transportation and fuel costs; because the packages are smaller, it requires fewer trucks for shipment; and distribution losses are minimized because it is easy to handle and does not break.<sup>5</sup>

One example of the cost benefits of using plastic film is reflected in DuPont's Mini-Sip™ package. The company, which provides packaged milk to schools across the country, recently decided to switch from using standard and slim-line milk cartons to using the Mini-Sip™ flexible pouch. The cartons require 13.3 and 10.2 grams of material respectively, whereas the pouch requires only 2.3 grams of material to deliver the same amount of milk. As a result of the switch,

- significantly less packaging material was needed to make the pouch;
- the energy used to produce the package decreased 72 percent;
- refrigeration space utilization increased 50 percent (at the dairy, on trucks and in schools); and
- there were fewer product losses because the pouches were hermetically sealed.

In addition, the schools that used the new milk pouch reduced the amount of waste in their trash cans because the uncompacted Mini-Sip™ took up 70 percent less space than the milk cartons and the amount of waste going from the schools into area landfills decreased by 90 percent because the compacted pouch took up even less space.<sup>6</sup>

#### Functionality

Another benefit of plastic film is that it can fulfill all of the necessary functions of a package, including containing and protecting a product as well as providing convenience and information to the consumer.

**Containment:** Containment simply means that a package must be able to hold a product and give the consumer a convenient way to transport it. For example, it would be very difficult and time consuming to move a dozen apples, 12 rolls of toilet paper, or frozen peas from the grocery store shelf, into the shopping cart, through the check out lane, out to the

car and into the home without a surrounding package. Because a film package can contain these and other products in the package and allows for easy transportation, it meets the packaging requirement of containment.

**Protection:** Protection comes in a variety of forms. For example, a film package used to contain clothing at a retail outlet protects it from dirt so that it is clean when the consumer buys and wears it. Similarly, the film around lunch meat helps keep the product free from bacteria; the film around potato chips keeps the product fresh and protects it from exposure to oxygen, moisture and light; and the film around fresh fruit protects it from insects and helps keep it clean. In these instances, the package made with plastic film is protecting the product from exterior influences that could harm and/or devalue the product.

A good package also helps preserve products. For example, the film around meat extends the product's life beyond what it would be in a case at the butcher shop. Similarly, the plastic film used to package cheese, fresh vegetables and bakery goods preserves the products inside because exposure to oxygen would substantially shorten their lives.

**Convenience:** Film in packaging and nonpackaging applications also provides convenience to consumers. For example, film can be clear, which allows consumers to see a product before they buy it or colored to protect the product from too much exposure to light. It can be fabricated in a variety of sizes—from a one-ounce candy bag to a 2,000-pound bulk bag used to hold powdered chemicals—which makes it ideal for very small and large products or products that are oddly shaped. Plastic film also can conform to the product, which helps save valuable shelf space at home and in the store. In nonpackaging applications, such as retail and storage bags, plastic film can be formed into packages with handles and drawstrings for easy carrying and zip-lock tops for repeated opening and closing. Plastic film also can be used as a mechanism to provide evidence of tampering with a product or package, important for consumer safety.

**Information:** Finally, plastic film can be printed, which means that manufacturers of a product can relay important information to the consumer, such as the name of the product, its ingredients and its value. In addition, instructions on how to use and/or prepare the product can be printed on the film package.

These examples demonstrate that plastic film can fulfill the necessary functions of a package, which, in

turn, has contributed to the growth of its use in packaging and nonpackaging applications.

### Versatility

Another benefit of plastic film is that it is versatile; it can be used alone, used in conjunction with other plastic resins or even used in conjunction with other materials, such as paper and aluminum. This versatility allows manufacturers to create packages that can perform very specific functions. Following are some examples of such packages.

**Single-resin, single-layer packages:** A produce bag that contains apples or potatoes is an example of a single-layer, single-resin package. It usually is made of one layer of LDPE or LLDPE and a metal crimp or twist tie is used as a closure device.

**Multi-resin, multilayer packages:** Some products, such as frozen vegetables, are designed to be cooked while still in a package. The bag used in this application—commonly referred to as a boil-in-bag—is made of three materials (two of which are film) and draws on the properties of different resins. It typically consists of a PET layer, which provides strength at the temperature of boiling water, and a polyethylene layer, which is needed for heat sealing. An adhesive is then used to hold the two layers of film together. Bubble packaging is another example of a multi-resin, multilayer film package, which is made with a combination of two nylon layers and one polyethylene layer.

Multi-resin, multilayer films are sometimes referred to as co-extruded films because they are made in a manufacturing process called co-extrusion. In this process, separate extruders are used to produce layers of different polymers. The layers are joined together in the liquid state just before the extrusion die. The combined layers then pass through the die to be cast or blown into one multilayer film.<sup>7</sup> Co-extrusion is desirable because it can take the best properties of different resins and join them together into a common structure that performs better than its individual parts.

**Multi-material packages:** Skin packages, which are increasingly used in hardware stores and retail outlets, are a good example of multi-material packaging. In

these packages, products such as nuts and bolts are placed on paperboard. A thin layer of plastic film (usually modified polyethylene) is heated and placed over the product and paperboard. The heat-softened film is then drawn down by vacuum to stick to the paperboard, thus sealing the product inside. This multi-material package, made of both paperboard and plastic film, is desirable because it is easy to handle (which helps reduce distribution losses), it cuts down on excess inventories and helps reduce clerical costs and pilferage at the retail level.<sup>8</sup>

**Metallized packages:** Some packages appear to be made with more than one material, but actually are made with just one specialized plastic film. A potato chip bag is a good example. Although it looks like it has an aluminum inner layer, it really is a micro-thin deposit of aluminum on the polypropylene, which is vaporized into the film (like a coating). This is referred to as “metallized” polypropylene. The aluminum coating is needed to block out ultraviolet rays, which would cause product degradation, and the polypropylene is needed to resist oxygen, which would turn the fats in the product rancid.<sup>9</sup>

All of the benefits discussed in this section of the report demonstrate why plastic film is used in packaging and nonpackaging applications and why its use has grown over time. Plastic film helps reduce waste at the source and in trash containers and landfills. It helps reduce costs during production, distribution and use. It minimizes product loss because of its unique properties and its ease of handling and storing. It performs all the functions required of a high-quality package. And, its versatility allows manufacturers to design packages to perform in very specific and necessary ways.

And, while plastic film use has grown in the past, it is expected to grow even more in the future. In *Modern Plastics Encyclopedia* (1996), Business Communications Company predicted an estimated 4 percent average annual growth rate in the demand for flexible plastic packaging until 1998. (The estimates are based on actual data from 1993 through mid-1995 and estimates for mid-1995 through 1998.)

HOW IS FILM WASTE MANAGED?

Waste Minimization/Source Reduction

The first and perhaps best, way of handling any kind of waste is to not create it in the first place—or, in other words, to minimize waste by reducing it at the source. As mentioned earlier in this report, plastic film, due in part to its high strength to weight ratio, has contributed significantly to waste minimization/source reduction efforts.

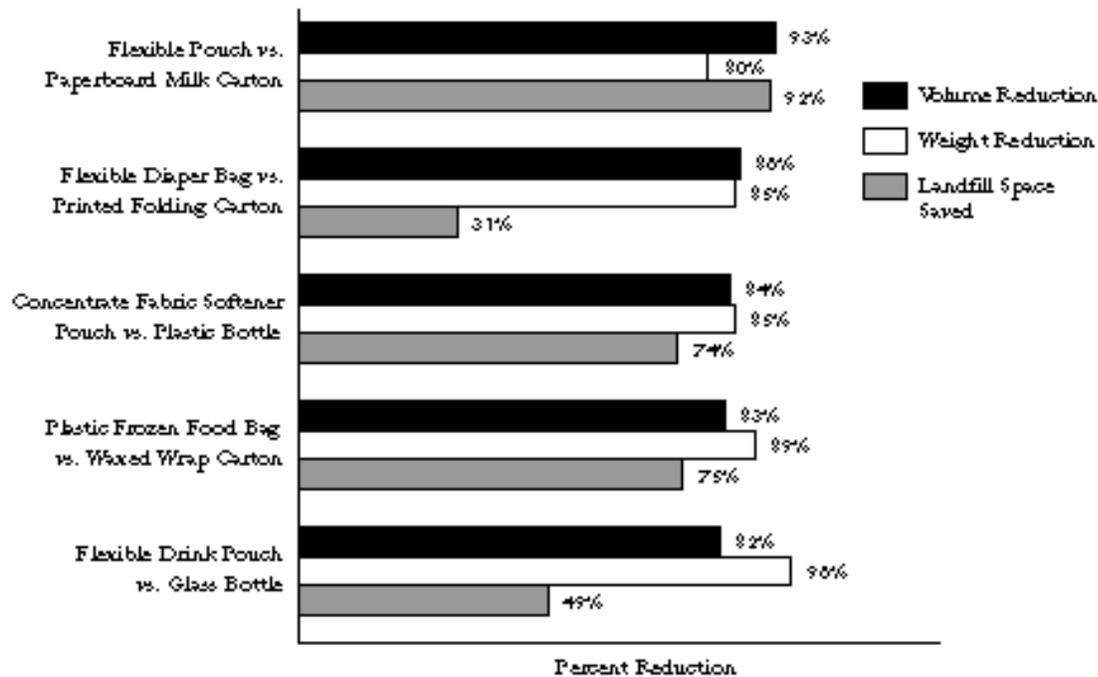
There are several other ways, however, that film has helped to reduce waste. One way is through the process known as thin-walling or down-gauging, where the walls of a package are made thinner while retaining the same performance characteristics. Using this technique, plastic grocery sacks are now 70 percent thinner than they used to be.<sup>10</sup> In 1976, the average sack was 2.3 mils thick, but by 1989 it was only 0.7 mils thick. That means that today it takes substantially less plastic to make the same number of

plastic grocery sacks, which is one example of waste minimization/source reduction.

The improved properties of film also have resulted in waste minimization. For example, the gas barrier properties of plastic films, like those used to protect some meats at the supermarket, have been improved to such an extent that product manufacturers now can use 25 percent less film without any loss in protection.<sup>11</sup> The film was reduced from 0.00048 inches to 0.00036 inches in thickness, which, again, means that manufacturers can use less plastic to make the same package and, thus, create less waste. In addition, the film packaging improves the shelf life of the product and helps reduce spoilage, both of which result in less waste.

Another way in which waste minimization/source reduction has been achieved is by substituting plastic film for containers made with other materials. This

**EXHIBIT 7**  
**Examples of Source Reduction Through the Use of Plastic Film**



SOURCE: Flexible Packaging Association (based on 1992 recycling rates)

happened in 1994 when Ben & Jerry's switched from using a dual-part package with an outer folding carton and an inner paper wrapper to package their Peace Pops™ and started using just one package made with polyester film. By making this change, Ben & Jerry's was able to prevent roughly 11 million boxes from going into landfills, which equates to 165 fewer tons of garbage each year.<sup>12</sup> Exhibit 7 shows some similar savings that were achieved when plastic film was used in place of packages made with other materials.

Plastic film, when used in combination with other materials, also can result in waste minimization. For example, coffee used to be packaged strictly in steel cans but now is also packaged in plastic/aluminum laminate brick packs. Some people believe that the steel can is more resource efficient than the brick pack because the former can be recycled but the latter cannot; however, this is not the case. Using equivalents to make the point, it would require 17 pounds of steel to hold 65 pounds of coffee, whereas it would require only 3 pounds of plastic/aluminum laminate to hold the same amount of coffee (which equates to a significant reduction in the amount of packaging needed to deliver the product and hence, the amount created and thrown away). And, even though the 17 pounds of steel can be recycled, it would have to be recycled at an 83 percent rate before the steel would be as resource-efficient as the plastic/aluminum brick pack.<sup>13</sup> In 1995, steel was only being recycled at a rate of 65.8 percent.

While waste minimization is a good thing in itself, it also has many other environmental benefits. For example, down-gauged or thin-walled products can reduce transportation costs by lightening the package and allowing more units to be loaded per truck for shipping; both of these things, in turn, help reduce the number of shipments necessary to deliver a product to market resulting in lower fuel usage and less stress on roads. Source reduction, because it creates less waste in the first place, also reduces the need to manage waste at the end of the stream through such mechanisms as recycling or landfilling. And, if a product's functionality or lifespan is increased by using film, it helps reduce the need to make replacement shipments and may extend the time it takes for a product and/or package to reach the disposal stage. Thus, the use of plastic film not only reduces the amount of waste created, it also helps conserve natural resources and reduces our reliance on other waste management options.

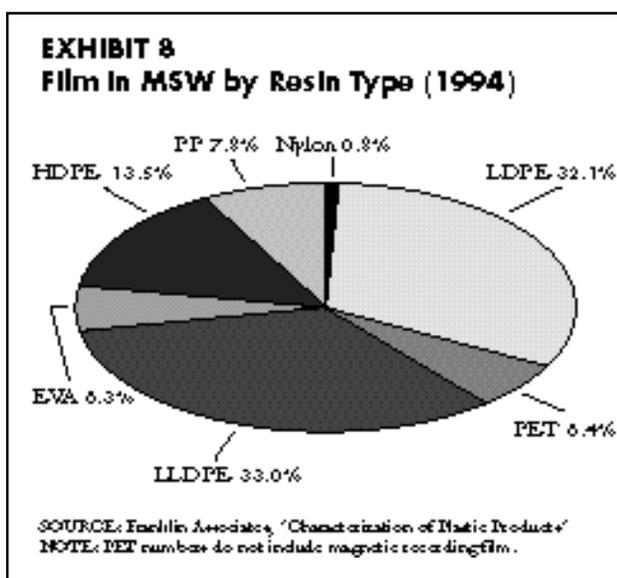
The problem with waste minimization/source reduction is that it is not easily measured. If a manufacturer, such as Ben & Jerry's, switches from using a dual package with an outer carton and inner paper wrapper to a single package of polyester film, that conversion is rarely publicized or even noticed. Therefore, while plastic film contributes substantially to source reduction and waste minimization efforts, the environmental benefits it affords often go unrecognized.

### Quantifying Plastic Film Waste

While reducing the amount of plastic waste created in the first place is important, there remains the question of how to manage the plastic film waste that is generated. To answer that question, you must first quantify how much plastic film waste is available.

A 1996 report prepared by Franklin Associates, entitled "Characterization of Plastic Products," found that, in 1994, there were approximately 44,344 million pounds of plastic in the municipal solid waste (MSW) stream. Of that amount, plastic film accounted for 11,245 million pounds, or 25.4 percent, of the plastic waste generated that year.<sup>14</sup> To put that number in perspective, total MSW equaled 209 million tons in 1994,<sup>15</sup> meaning that plastics of all kinds composed about 10.5 percent of MSW by weight and plastic film composed 2.7 percent.

Exhibit 8 breaks the film found in MSW down by resin type. As you can see, LLDPE composes the largest portion of the plastic film waste stream at 33.0 percent, followed closely by LDPE at 32.1 percent; HDPE is a distant third at 13.5 percent and PP,



nylon, PET and EVA make up the remaining 21.4 percent.

The Franklin Associates data also indicate that, on average, 72 percent of film waste is generated in the residential sector and 28 percent is generated in the commercial sector. (Similar data on plastic film in the

industrial waste stream are not currently available.) The exact proportions, however, vary considerably among resin types. For example, 80 percent of PP film is found in the residential sector, which is higher than the average, whereas only 50 percent of nylon film is found in the residential sector which is lower than the average.

EXHIBIT 9:  
Film in the Residential and Commercial  
Waste Streams (1994)

	Residential		Commercial	
	Million Pounds	Percent	Million Pounds	Percent
<b>LDPE</b>				
Food Packaging	942	80	236	20
Nonfood Packaging	930	80	232	20
Shrink Wrap	79	50	79	50
Stretch Wrap	37	50	37	50
Carryout Bags	99	80	25	20
Trash and Can Liners	168	60	112	40
Other	318	50	318	50
<b>LLDPE</b>				
Food Packaging	249	80	62	20
Nonfood Packaging	627	80	157	20
Stretch Wrap	421	50	421	50
Carryout Bags	217	90	24	10
Trash and Can Liners	715	60	477	40
Other	569	50	173	50
EVA	569	80	142	20
<b>HDPE</b>				
Food Packaging	138	60	34	40
Nonfood Packaging	121	80	30	20
Grocery Sacks	564	90	63	10
Other Retail Bags	76	90	8	10
Trash Bags and Liners	178	50	178	50
Other	65	50	65	50
<b>PP</b>				
Oriented	563	80	141	20
Unoriented	136	80	34	20
Nylon	44	50	44	50
PET	652	90	72	10

SOURCE: Franklin Associates, "Characterization of Plastic Products," 1996

NOTE: PET numbers do not include magnetic recording film, which is evenly split between residential and commercial waste streams.

Distribution by waste stream also varies considerably by application. For example, half of all LDPE stretch and shrink film is found in the commercial sector as is half of all HDPE trash bags and liners. Exhibit 9 shows the distribution of resin types and applications by sector where the data are available. It should help in identifying where to look for certain types of film waste.

Like most packaging and nonpackaging materials, plastic film waste can be handled in a variety of ways. The following section looks at the three waste management options that are typically used to manage film waste once it is created.

### Landfilling

To date, landfilling is the method used most often to handle the plastic film waste that is created.

According to data compiled by Franklin Associates, 8,636 million pounds, or 76.8 percent, of the plastic film discarded in 1994 ended up in a landfill. Exhibit 10 shows the amount of film waste landfilled by weight, by resin and by application where such information is available.

Franklin Associates arrived at these figures by quantifying plastic film discards, subtracting the amount of film recycled and subtracting the amount of waste combusted that year, which was calculated at 21.9 percent of discards. (Please note that the numbers are based on 1994 data and, therefore, are not comparable with the 1995 recycling numbers shown in the following subsection on recycling.)

When plastic film reaches the landfill, it does not present environmental problems because of its inherent inertness; the material itself does not cause leachate problems and does not contribute significantly to the production of methane (the by-product of the degradation of organic materials). Film also is preferable to some other kinds of waste because it is flat, low in volume and easily compressed, all of which are desirable characteristics in landfill situations.<sup>16</sup> In fact, contrary to presenting problems in landfills, plastic film—in the form of liners that are commonly made of PVC, polyethylene and/or rubber—can play an important role in protecting groundwater from landfill leachate. Plastic is chosen in this and other applications because of its stability.

### Combustion

The most recent data available on the amount of plastic film combusted are found in the Franklin

Associates study, entitled “Characterization of Plastic Products.” In that study, Franklin reports that 2,420 million pounds of plastic film were combusted with or without energy recovery in 1994 (although it explains that most waste combustion does include energy recovery). Franklin calculated combustion at 21.9 percent of total discards across the board. (The study also notes that, in 1994, the U.S. average rate of combustion was estimated at 15.5 percent of total waste generation.) Exhibit 10 shows the amount of film combusted in 1994 by resin and application where such information is available.

How plastic film behaves during combustion varies by resin and application because different types of plastic have different combustion properties. In an article entitled “Plastics and Waste-to-Energy Combustion,” J. Winston Porter, an environmental consultant and former Assistant Administrator for Solid Waste and Emergency Response at the EPA, explains that plastics do not cause problems in waste-to-energy (WTE) facilities because they are

...derivatives of hydrocarbons with contaminants such as sulfur largely removed. Plastic wastes, or any organic additives to plastic, produce carbon dioxide and water when combusted. With respect to heavy metals, plastic wastes contribute almost no mercury or lead, but do provide about one-quarter of the cadmium in trash. Fortunately, cadmium levels in WTE air emissions are reduced to very low levels by the pollution control equipment. Also, cadmium is being reduced in colorants and other plastic uses.<sup>17</sup>

Porter also explains that plastics have properties that make them a valuable part of WTE combustion. For example, they have very high heat values, which helps facilities burn material more cleanly and completely, resulting in a more efficient conversion of trash to energy and less residual ash. In his article, he compares plastic waste, which generates between 12,000 and 18,000 Btus per pound, to other sources of energy such as general trash, which generates only 5,000 Btus per pound; waste paper, which generates 8,000 Btus per pound; and coal, which generates 9,000 Btus per pound. Because of their high heat value, plastics are considered a beneficial material to use in WTE facilities.

In recent years, there has been some concern about what happens when products and packages containing chlorine are burned. There are, however, two

important facts to keep in mind when considering combusting post-consumer plastics. First, there have been a variety of independent research investigations conducted both in this country and abroad to determine more precisely what happens to chlorine during

combustion. Two such recent investigations—one conducted by the American Society of Mechanical Engineers and another conducted by the Association of Plastics Manufacturers in Europe—found that changes in chlorine content do not measurably affect

EXHIBIT 10:  
Plastic Film Applications by  
Waste Management Option (1994)

	Combustion		Landfill	
	Million Pounds	Percent	Million Pounds	Percent
<b>LDPE</b>				
Food Packaging	258	22	920	78
Nonfood Packaging	254	22	908	78
Shrink Wrap	35	22	124	78
Stretch Wrap	15	20	54	73
Carryout Bags	22	18	80	65
Trash and Can Liners	61	22	219	78
Other	139	22	496	78
<b>LLDPE</b>				
Food Packaging	68	22	243	78
Nonfood Packaging	172	22	612	78
Stretch Wrap	172	20	613	73
Carryout Bags	44	18	156	65
Trash and Can Liners	261	22	931	78
Other	76	22	271	78
<b>EVA</b>	156	22	555	78
<b>HDPE</b>				
Food Packaging	38	22	135	78
Nonfood Packaging	33	22	118	78
Grocery Sacks	135	21	481	77
Other Retail Bags	18	22	66	78
Trash Bags and Liners	78	22	279	78
Other	29	22	102	78
<b>PP</b>				
Oriented	154	22	550	78
Unoriented	37	22	133	78
<b>Nylon</b>	19	22	69	78
<b>PET</b>	146	20	521	72

SOURCE: Franklin Associates, "Characterization of Plastic Products," 1996

NOTE: LDPE and LLDPE grocery bags are included in the "carryout bag" category. Also, if these rates are used to calculate a recycling rate, they will not be comparable with the rates shown in Exhibit 11. That is because the two exhibits use different base years. For the most current data, use Exhibit 11.

the composition of dioxins and furans in flue gases.<sup>18</sup>  
<sup>19</sup> The studies explain that, under controlled conditions and at temperatures typically greater than 1100 degrees Fahrenheit, dioxins and furans are destroyed in WTE facilities. If associated with fly ash, these chemicals become trapped by pollution control equipment, including high-performance electrostatic precipitators or fabric filter baghouses. Newer technologies—such as activated carbon injection systems that blow charcoal into the exhaust gas—can further reduce levels of such emissions to well below regulated limits.

Second, when looking specifically at PVC film, the resin is used in such small quantities that any possible negative impacts associated with combustion would be negligible. As the data in Exhibit 1 show, PVC film and sheeting combined compose less than 4 percent of the resin sold into film applications. Film of all resins represents only 2.7 percent of the total municipal solid waste stream.

Therefore, for these two reasons, there should be very few concerns, if any, about combusting PVC film.

### Recycling

At present, some plastic film is being recycled, although not nearly at the rates of rigid plastic containers. Breakdowns of information from R.W. Beck's 1995 National Post-Consumer Plastics Recycling Rate Study show that approximately 189.7 million pounds of selected film resins were recycled in 1995

(Exhibit 11). That means that the overall recycling rate for those film applications on which data are available was 3 percent. LDPE/LLDPE stretch and shrink film has the highest individual recycling rate at 7.3 percent, followed by LDPE retail bags (5 percent) and HDPE retail bags (3.4 percent).

The amount of film recycled probably is slightly higher than Exhibit 11 shows because some film resins that are being recycled are included with other plastic products in a category called "other packaging" or "other applications" instead of a separate category for film. In the R.W. Beck data, this is true of PET x-ray film, HDPE garbage bags and agricultural film, LDPE trash bags and agricultural film, PP film and very small amounts of PS film that are used for packages and labels.

Although there is no one source of information on recycling rates for these "other" types of film, some industry experts have been willing to share estimated recycling data. For example, agricultural industry sources report that approximately 20–25 million pounds of greenhouse and nursery film are being recycled each year in the United States and Canada. These two types of agricultural films are targeted most often for recycling because they are fairly clean (compared with mulch films, which are contaminated with dirt) and readily accessible in relatively large quantities (unlike films generated by individual farms). Similarly, sources inside the polyester industry estimate that approximately 80 million pounds of PET film are being recycled annually from x-rays. These numbers

EXHIBIT 11  
 U.S. Film Recycling Information (1995)

	Millions of Pounds Recycled	Virgin Sales	Recycling Rate (Percent)
<b>HDPE</b>			
Film Packaging	8.4	338	2.5
Retail Bags	25.8	750	3.4
<b>LDPE</b>			
Shrink/Stretch Wrap	81.9	1,115	7.3
Film Packaging	54.5	3,036	1.8
Retail Bags	16.3	325	5.0
PP Flexible Packaging	0.1	697	0.0
PVC Film and Sheet	2.7	622	0.4

SOURCE: R.W. Beck and Associates, 1996

### PLASTIC GARBAGE BAGS: PART OF THE SOLUTION

Plastic garbage bags are made of film and, therefore, considered a potential target for film recycling programs. But while some garbage bags are indeed being recycled, it is important to keep in mind their original intended end use—as containers for waste headed to the landfill. In that sense, garbage bags play a key role in waste management efforts.

As waste management options have increased, so have the uses for plastic garbage bags. For example, today they are being used to contain and transport (1) yard and food wastes to compost facilities, (2) bottles to distributors in bottle bill states and (3) recyclables to materials recovery facilities (MRFs) and other processing facilities. Sometimes the bags used in these applications can be cleaned up and recycled into new products, but other times they may be too contaminated for further use. Even in the latter instance, however, the garbage bags have still played a role in managing waste and have fulfilled their primary function.

typically are not reported in film recycling studies, but may show up under silver recovery.

As will be discussed later in this report, film recycling seems to work best in situations where large volumes of like film (i.e., film made with the same resin) and with low rates of contamination are generated. For example, stretch film recycling programs implemented at warehouse and distribution centers, grocery store chains and bulk mail facilities have proven quite effective. They generate enough material to make densification and transportation feasible; there are relatively low levels of contamination because the film is not exposed to large amounts of food, dirt, other plastic or other materials; and recycling film instead of landfilling it provides an economic incentive for recovery. There also has been success with recycling plastic grocery sacks collected at grocery stores and with some agricultural films—like greenhouse film and silage bags—that do not have high levels of contamination or degradation.

Once recycled, film can be used to manufacture a variety of products. For example, it is used in nonfood film applications, such as stretch wrap, trash bags and liners, construction film, grocery sacks and retail bags. It also is used in household products, like garbage

cans, wastebaskets and recycling bins. And, it is used widely in plastic lumber, which can be made into such things as picnic tables, benches, playground equipment, sign posts, marine pilings, decking and furniture. As manufacturers become more skilled in using recycled film, the demand for the material is expected to increase.

This section on waste management strategies for film demonstrates that there are a number of ways in which communities can deal with this particular waste stream. Film has excellent source reduction attributes; its high heat value is an asset to WTE facilities; it does not appear to present environmental problems in landfills or at WTE facilities; and it can be recycled in circumstances where large quantities of like material with low levels of contamination are generated and where markets are available. Therefore, the method or combination of methods that a community chooses for managing film waste will depend on local capabilities (such as the availability of recycling facilities, WTE facilities and landfill space), local preferences and priorities (such as laws or ordinances that prescribe waste management practices and hierarchies) and local economics. In other words, there is no one “right” way to manage film waste.

## WHAT DOES FILM RECYCLING INVOLVE?

For those communities, organizations and/or businesses that want to pursue plastic film recycling, there are several pieces of information that should be factored into the decision. The following section identifies many of those factors, all of which will need to be addressed in order for film recycling to succeed.

### Film Recycling Processes

While the way that film is recycled will vary from facility to facility, there are three basic levels of processing that are commonly used to put recovered film back into a form in which it can be used to make new products.

**Washing and Repelletizing:** In this most extensive process, film comes into the recycling facility, typically in baled form. It is then pulled apart by hand or cut open using a guillotine. The film is fed into a shredder to make it more manageable and then fed into a water-fed grinder where it is reduced to pieces that measure about one-half of one inch in size. (Grinding is necessary to get film into a form in which it is easier to wash and extrude.) After grinding, the film is conveyed into washing equipment. Most systems today use only water as opposed to water and surfactants. The water is agitated, which forces the material to rub against itself, helping to break down paper labels, loosen dirt and remove other forms of contamination. (This action is much like the agitation that helps get clothes clean in a washing machine.) While in the water, centrifuge or hydrocyclone technology is commonly employed to encourage fibers and other heavier materials to sink to the bottom of the tank for removal. The plastic film, which is lighter and tends to float toward the surface, will be skimmed off and conveyed to a dryer. Once dry, the clean, ground film flake is melted and extruded through screens that are used to filter out any remaining impurities. This is the point at which pellets are produced and cooled (with either water or air) so they can then be used in manufacturing.

**Dry Processing and Repelletizing:** In this process, which is typically used for cleaner sources of film (such as stretch or shrink wrap that is relatively free from labels), the film is shredded and ground without water and fed in flake form directly into an extruder where it is turned into pellets. In this system, the screens used in the extruder become the primary mechanism for removing contaminants from the film;

the screens have openings of various sizes depending on the level of contamination of the incoming film and the end product that is being manufactured. In general, screens with smaller openings will help filter out more impurities, but they require more pressure to push the plastic through the extruder and take more processing time.

**Converting Ground Film Directly into a Product:** In this process, recyclers bring film into their facilities, again usually in baled form. The film is pulled apart by hand or cut open using a guillotine and fed first into a shredder and next into a grinder. Once the film is ground, it is then used in that form to manufacture a new product (i.e., it is not washed or pelletized prior to use). Clearly, this process is the most desirable of the three because it is much less labor and equipment intensive, but it can only be used in instances where the incoming film is of very high quality and/or the end product is very forgiving of contamination.

Of these three processes, the one that is selected for recycling film will depend on (1) the type and source of the material that is being recycled, (2) the level of contamination and (3) the application in which the recycled film is being used. For example, if a facility were converting commercially generated stretch film that is relatively free from contamination (a high quality feedstock) into plastic lumber (a more forgiving application), then that facility may be able to convert the film in ground form directly into a finished product. If, however, a facility were converting greenhouse film (a lower quality feedstock) into trash bags (a less forgiving application) they probably would need to wash and repelletize the material.

There is another process that is being used, although on a more limited basis, to recycle film.

**Densification/Agglomeration:** In recycling, densifiers (which are more commonly referred to by industry as agglomerators) typically are used in place of shredding, grinding and repelletizing equipment. Agglomerators rely on a two-phase process (both of which occur almost simultaneously) to turn film into a form in which it can be used more easily in manufacturing. In the first phase, all densifiers use the same basic principal of heating and size-reducing film through some type of mechanical friction to bring it up to its gel point. This can be accomplished either

### CPR USES DENSIFICATION EQUIPMENT TO RECYCLE FILM

Consumer Plastics Recycling (CPR), a plastics handler located in Denver, Colorado, is using densification equipment to recycle plastic film. Founded in 1994, the company now handles polyethylene film and grocery sacks collected through a statewide recycling program sponsored by King Soopers, as well as LLDPE stretch wrap collected through a cooperative commercial collection program.

Although CPR was able to market the film to other reclaimers, the company decided to start reclaiming the material itself in order to add value and expand their market base. CPR used a grant from the American Plastics Council's Technical Assistance Program to purchase a Cal-Sierra 200-horsepower, vertical-mount densifier to produce batches of densified flake that can be mixed with virgin resin in extrusion applications. Between 100 and 200 pounds of loose film per batch are manually fed into the densifier's large, open-top circular hoppers. A rotary blade spins at the bottom of the hopper, shredding the material and generating enough heat to melt the plastic into a soft, homogeneous "doughnut." Cold water is sprayed onto the softened material, which then solidifies into granules or small flakes. Each batch takes five to ten minutes to produce, yielding 1,000 to 1,500 pounds of reclaimed flake per hour.

The Denver area features a number of potential markets for CPR's post-consumer flake. For example, three of the nation's four slip sheet manufacturers are based in the Denver area. One of these companies, Repsco, worked closely with CPR in developing product specifications for the recovered material. CPR also sells its reprocessed film to companies that produce plastic lumber for use in such products as picnic tables and car stops.

In a current joint project with the American Plastics Council, the Colorado School of Mines and PDM Molding, Inc., CPR is working to identify the physical properties of LLDPE recycled stretch film in specific manufacturing processes, including rotational molding. The project will test various combinations of recycled and virgin LLDPE for such features as strength, elasticity, durability, weathering and impact resistance. (For more information, contact CPR at 303/295-3577.)

through rotary chopping in a drum-type densifier or through high-pressure compression. (High pressure compression can be achieved with an extruder-type auger, through rotating plates with a varied gap or through other similar mechanisms.) This first phase is desirable because it significantly reduces the bulk density of film without resulting in thermal degradation. In the second phase of agglomeration, the material is formed into a granule or irregular pellet through one of several processes. For example, in one process the softened plastic is quickly cooled, which, with the help of a rotating blade, causes the material to fracture into small pieces or granules. Other processes involve the use of pressure (or extrusion) to push the material through rotating plates, augers or nested drums. Once the material leaves the pressure point, it solidifies and may then be cut into small granules or irregular pellets.<sup>20</sup>

For years, agglomeration has been used by virgin resin producers to process their own in-house film scrap for reuse in their products. (In fact, agglomerators tend to work best on clean sources of scrap because they trap contaminants in the densified chunks of plastic.

These contaminants cannot be removed easily through washing.) Recently, however, densifiers have also been finding their way into the plastics recycling industry.

### Film Recycling Equipment

Many people interested in recycling film ask a common question: "Is special equipment needed to recycle film or can conventional plastics recycling equipment be used (i.e., equipment similar to that used to recycle rigid containers)?"

That question is somewhat difficult to answer. The basic technology used to recycle film is similar to that used in standard plastic recycling systems in that balers, shredders, grinders, wash/dry systems and extruders are used in both instances. As is true with any recycling system—whether the material being recycled is film, bottles or something else—the equipment needs to be designed or modified to accommodate the unique characteristics or behaviors of each material and be capable of producing a feedstock that will meet end-user specifications. Therefore, because film behaves differently in equipment than the way-

rigid plastics behave and because end users of recycled film have different requirements, the equipment used to recycle film must be designed or modified to meet those special needs.

The following is a brief discussion of some of the special considerations that must be taken into account when making purchasing decisions about film recycling equipment.

**Balers:** A standard baler, like that used for corrugated cardboard, can be used for plastic film; there are, however, balers designed specifically to densify film. The latter balers may be preferable because they yield denser bales and, thus, help improve efficiencies and lower transportation costs. If a standard baler is used to bale plastic film and other materials like corrugated cardboard, then collectors and processors must be sure to clean the baler between materials to reduce the potential for cross-contamination. In addition, most film markets ask that collectors and processors limit the use of headers when baling film. ("Headers" are materials like corrugated cardboard or plastic slip sheets that are used to hold bales together and make

wrapping them more convenient.) Film markets dislike the use of headers because they have to be thrown away, which adds to their waste stream as opposed to their recycling stream. And, since markets pay by the pound to dispose of waste, headers add to the costs of their recycling operation.

**Grinders:** The same or a lighter grinder can be used for processing both bottles and film, but because film is softer, thinner and more malleable than rigid plastics, the blades must be appropriately sharp in order to shear the film (otherwise, it will wrap around the blades and clog the equipment). For that reason, many processors opt to purchase a grinder specifically designed to accommodate film characteristics. Another consideration that should be taken into account is the type of system the film is being processed in. If the recycling system washes film, then a water-fed grinder is preferable, whereas dry grinders should be used in dry systems.

**Washing Systems:** Washing systems for film are different from those used for bottles in two significant ways: (1) most film wash systems use only cold water

#### SILAGE BAGS: AN AGRICULTURAL FILM RECYCLING PROGRAM

Silage bags are one type of agricultural film that is currently being recycled, although on a relatively small scale. Silage bags measure about 8 to 12 feet in diameter, 100 to 250 feet in length and weigh about 100 to 200 pounds when empty. (The bags weigh between 300 and 400 tons when full, which gives some idea of their size and storage capacity.) They usually are made of LDPE, LLDPE or a combination of LDPE, LLDPE and EVA. The bags are used primarily by dairy farmers and cattle ranchers as a low-cost way to store corn silage (or wet feed) on the farm or ranch. It is not uncommon for large farms and ranches in the West to use 20,000 pounds of silage bags per year. (Conversely, small farms in New England that average 100 head of livestock may use only one or two silage bags per year.)

In 1993, Ag-Bag International Ltd.—an agricultural manufacturing company, located in Warrenton, Oregon, that folds and boxes silage bags and makes the machines needed to fill them—started a silage bag recycling program for its customers located in the southwest corner of the country. It implemented the collection program there because it has such a high concentration of customers (mostly individual farmers) located in southern California, New Mexico and Colorado, each of which generate significant quantities of material.

When the silage bags are empty, participating farmers rinse them out and store them wherever they can find room. (Some farmers will even cut them up into smaller, more manageable pieces.) When they have accumulated as many as they can store, the farmers and ranchers call Ag-Bag, which sends out a specialized collection vehicle. The vehicle consists of an 18-foot flatbed and a 24-foot trailer with a horizontal baler and a "cherry picker." The operator uses the cherry picker to pick up the waste silage bags from piles at the farm or ranch, shakes off loose contamination and loads the baler hopper. The baler produces 1,200-pound bales that are loaded onto the truck's flatbed. The bales are then stored at an Ag-Bag facility until a back-haul can be provided by Poly-America (Ag-Bag's supplier of original bags and end market for recovered bags). At Poly America, the bales of silage bags are broken open, the material is then shredded, ground, washed, dried, extruded and repelletized. The recycled pellets typically are sold for use in such applications as construction film and trash bags. (For more information, contact Ag-Bag International at 503/861-1644.)

whereas bottle wash systems use hot water and (2) film systems do not employ caustics or surfactants whereas bottle systems do. One of the reasons why the wash systems are designed differently for the two materials is because they have somewhat different goals or priorities for removing contaminants. For example, colors from printed labels are a serious concern for bottle recyclers but not as serious for film recyclers (at least those that use film in pigmented or darker colored products like trash bags or lumber). Therefore, bottle wash systems need more force (i.e., heat and surfactants) to remove printed labels that contain colors. Dirt, however, is a more serious concern for film recyclers, particularly those that deal with stretch wrap, because it attracts dirt and paper fibers because of its tacky surface. Because of these differences, it may make sense for film recyclers to purchase a system specially designed for cleaning film and addressing its particular contamination concerns.

**Extruders and Pelletizers:** The primary difference between extruders designed for processing film and those designed for rigid containers is the feeding mechanism. Because flakes from rigid containers are heavier, hoppers, which rely on gravity, can be used to feed plastic into the extruder. Film fluff, however, is so light that gravity is not an effective feeding tool (the material will simply ball up and bridge across the hopper). Thus, film processors typically will use either a densifier on the front end of the extruder or a stuffer to force the fluff into the equipment. The same pelletizer can be used, though, with both rigid plastic and film, because once the material is melted the equipment cannot sense any difference.

### Challenges in Film Recycling

In addition to understanding film recycling processes and special equipment needs, communities, organizations and/or businesses also need to understand that there are several challenges related to film recycling that must be addressed if programs are going to succeed.

**Volume:** One thing that recyclers have learned from recycling plastic bottles and containers is that volume is one of the keys to program success. The more quickly a recycler can accumulate large quantities of a particular material, the more likely he or she will be to (1) find a market for it, (2) realize transportation efficiencies and (3) avoid lengthy storage durations.

The same thing is true with recycling plastic film, which is why most successful programs are run by organizations—such as grocery store chains, retail

chains and bulk mail facilities—that have one or more warehouse and distribution centers (W/DCs). W/DCs receive large quantities of goods on pallets, which they disassemble, rewrap and distribute downstream to other outlets and/or customers. Thus, they can collect the film generated in their own facility (which is often quite substantial), add to it the film generated by their outlets and/or customers and accumulate enough material in a short time to market full truckloads of film (usually in the form of stretch wrap, shrink wrap and/or grocery sacks). In addition, places that own their own trucks, such as grocery stores and the postal service, can use a back-haul approach to pick up film (which is usually stored loose in bags) from their own outlets. That, in turn, eliminates the need for storage space at the outlets and allows the W/DC to minimize transportation costs (since trucks are already going in one direction).

Other places that may generate substantial quantities of like film include furniture and mattress manufacturers (which ship goods covered with film), producers of film packaging (which may have trim stock and/or defective products), food processors that package food in film, hospitals and medical supply companies and assembly plants (that have large quantities of parts shipped to them).

Unfortunately, outside of the above examples, there are few large generators of like types of film. Instead, film is found more often in small- to medium-size businesses, which have a difficult time amassing enough material to make recycling worthwhile. For example, if a local retail store wants to recycle stretch wrap but is not part of a larger chain, it will need the film unwrapped from 2,000 skids or 50 truckloads of incoming goods just to make one 1,000-pound bale. (The rule of thumb is that you can generate six to eight ounces of stretch film per pallet.) Similarly, if a local grocery store wants to recycle plastic sacks, it will take about 61,500 sacks to make an 800-pound bale. (The rule of thumb is that 1,000 sacks on average weigh 13 pounds.) If these establishments generated one bale per month, it would take three years to get enough film to make a truckload.

This does not mean that individual grocery stores or other small- to medium-size businesses cannot recycle film, but they will have to be more creative about it. For example, they may want to become part of a cooperative collection effort in which several generators in close geographic proximity work together to collect and market their stretch film. (See the sidebar on the WRAP Cooperative Film Collection Program

### THE WRAP COOPERATIVE FILM COLLECTION PROGRAM

The Workplace Alliance for Plastic Recycling (WRAP) is a good example of a cooperative film recycling program. It was created when two companies—Coors Brewing Company and Ball Metal Beverage Container—began looking at their waste streams to determine whether there was any material that could be recycled instead of landfilled. Both companies identified stretch wrap as a potential target, but they knew that, alone, they could not generate enough material quickly enough to attract a market. Therefore, they decided to try to market their stretch wrap together.

In February 1993, Coors and Ball held a meeting with several of their customers whom they knew were also using significant quantities of relatively clean stretch wrap. At that meeting, six additional businesses agreed to participate with Coors and Ball in a cooperative marketing program. It was decided that each company would set up its own internal collection program and make its own arrangements for transporting the stretch wrap—either in loose or baled form—to one designated market. The members of the group worked together, however, to (1) secure a broker, (2) establish quality control standards, (3) develop joint educational materials and (4) solve common problems.

WRAP has evolved considerably since its inception in 1993. It now has 24 members, including representatives from food, beverage and health-related industries as well as textile, paper and packaging distributors. The group also has a program coordinator who handles all arrangements with the market and provides assistance with transportation. For example, several of the WRAP members have formed “truck pools,” where shared vehicles pick up partial loads of stretch wrap from each location on a given day and transport the full load to the processor (thereby minimizing transportation costs).

Since the program's inception, participating companies have recovered more than 500,000 pounds of stretch wrap for recycling. At present, the collected material is delivered to Consumer Plastics Recycling (CPR), a processor of post-consumer plastics located in Colorado. CPR then sells the reprocessed material to Denver-based companies that use the material to manufacture recycled plastic lumber and slip sheets. Any profits that are generated as a result of marketing the stretch wrap are donated to charitable organizations as opposed to going back to individual participants. (For more information, contact the W.R.A.P. Coordinator at 303/466-1848.)

for more information on how a cooperative works.)

**Storage Space:** Another complicating factor related to volume is storage space. Since small- and medium-size organizations do not generate large quantities of film in a short time frame, they need space to store the material until they accumulate enough to move. As an example, if a small store were to receive 200 pallets of goods per month, it would generate only 100 pounds of stretch film or enough to fill two gaylord boxes (42-inch cubes). It takes approximately 20 gaylords to make one 1,000-pound bale of stretch wrap and a gaylord takes up 12.25 square feet of space on the floor. Therefore, the store would need 245 square feet of space to store the stretch wrap for 10 months until it could make a bale—space a small store probably does not have.

**Collection Infrastructure:** Outside W/DCs, there is no real infrastructure in place for collecting film. There are brokers that consolidate film from a variety

of sources, but they usually require a relatively high volume for participation. There also is some film recycling activity that takes place between local companies through waste exchange programs, some commercial MRFs are starting to explore the feasibility of collecting and recycling film and there are some cooperative marketing projects in which companies in a close geographic area consolidate film and sell it together. But, at this time, there is no real or pervasive infrastructure for collecting film and few consolidation points where small- to medium-size generators can combine smaller lots. Therefore, one of the most significant challenges facing film recycling is how to develop the infrastructure so that more commercial and institutional outlets can participate.

**Cross-resin Contamination:** Another challenge that needs to be addressed in film recycling is the contamination that results when films made with different resins are mixed together. Similar to plastic bottles and containers, the resins used to produce film each

have unique properties that ideally should be preserved in the recycling process if film is going to be put into higher end applications. For example, if a recycler wants to make stretch wrap with good

#### W.R.A.P. / VOLUME

strength characteristics from recycled content, then it will need stretch wrap—and only stretch wrap—as a feedstock.

#### SPARTAN / WHEREVER

Similarly, different resins have different melt temperatures that can cause problems in remanufacturing. For instance, the applications in which film from a co-extruded package made with PE and nylon can be

#### POSTAL / WHEREVER

used will be limited because PE melts at a relatively low temperature and nylon melts at a high temperature. Thus, the resulting recycled film product may have gels in it from the unmelted nylon.

If films made with different resins and with different melt temperatures are mixed together, it does not necessarily mean that they cannot be recycled, but it does mean that they will have go into more forgiving applications. For example, if LLDPE stretch wrap and

LDPE shrink wrap are mixed together, the material probably will not be acceptable for manufacturing new stretch or shrink wrap, but it probably will be acceptable for manufacturing plastic lumber, some agricultural films or even some high-gauge trash can liners and bags. What recyclers have to realize, though, is that as material moves down the chain, its value decreases.

Unfortunately, understanding the need to separate film by resin does not make it easy to do, because there are few good ways to tell different film resins apart. When starting a film recycling program, generators and/or processors should consider the following approaches to identifying film resins:

- First, have a good understanding of the general applications in which different film resins are used. Exhibit 12 has a fairly comprehensive (although not exhaustive) list of film applications by resin type, which provides some general information on the resins one may be dealing with. Of course, such knowledge is less useful if recycling programs are designed to collect diverse streams of film from a wide range of suppliers.
- Second, whenever possible, generators of film waste should ask their own suppliers for data sheets. For example, a furniture manufacturer can contact the supplier of its protective film covers to learn what the film is made of; it, in turn, can relay that information to its furniture outlets that want to collect film for recycling and generators can share that information with their markets/processors.
- Third, processors should test film from each generator/supplier before a contract is signed. That will give the processor an idea of what to expect in terms of content and quality from that particular generator. Then, once the processor signs a contract, it is standard procedure to test loads periodically to ensure that the loads continue to meet market specifications over time.
- Fourth, if a generator wants to start recycling film but does not know what type of film it has, it could have a sample tested in a certified laboratory. Some lab tests can be expensive and time consuming and may only determine what resins are present but not in what quantities; therefore, outside testing probably makes the most sense in those circumstances where cost is less of a factor and where there is a known consistent supply of material that is not likely to change over time.

**EXHIBIT 12**  
**Selected Film Applications by Resin Type**

<b>LDPE/LLDPE</b>	<b>HDPE</b>	<b>PP</b>
shrink wrap	bakery bags	cigarette wrap
stretch wrap	bag-in-box	candy wrappers
produce bags	carton liners	snack food bags
bakery bags	cereal mix bags	shrink wrap
bag-in-box	cake mix bags	textile bags
boil-in-bags	produce bags	tape
candy bags	shipping sacks	bakery bags
ice bags	envelope film	cheese packaging
rack and counter bags	industrial liners	medical packaging
grocery bags	retail bags	sanitary goods packaging
merchandise bags	grocery sacks	sterilization wrap
self-service bags	T-shirt bags	diaper coverstock
garment bags	merchandise bags	tobacco wrap
trash bags and liners	self-service bags	metallized bags
household wrap	trash bags and liners	
carton liners	mulch film	<b>PET</b>
bubble packaging	fumigation film	x-ray film
envelope film	construction film	camera film
industrial liners		audio recording film
overwrap	<b>PVC</b>	video recording film
shipping sacks	carton liners	drafting film
textile bags	bags and sacks	solar control film
mattress bags	stretch film	overheads
greenhouse film	shrink film	ink jet film
nursery film	red meat wrap	labels
mulch film	adhesive tape	tobacco wrap
degradable mulch film	labels	cigarette wrap
fumigation film	blood bags	metallized bags
silage bags	I.V. bags	
haysleeve covers		
peat moss bags		
fertilizer bags		
construction film		

One possible alternative, however, is to have a sample tested by companies that offer testing as one part of their service. Two companies involved with recycling have recently started offering such testing services for film: Talco Plastics, Inc., in North Long Beach, California (310/630-1224) and wTe Corporation in Boston, Massachusetts (617/825-9244). A nominal fee may be charged by these companies to perform the test depending on the the level of work required.

**Lamination and Co-extrusion:** Cross-resin contamination occurs when films made with different resins are mixed together in collection and processing. It also can occur when processors recycle multilayer

films. These films typically are made in one of two manufacturing processes—lamination or co-extrusion. The lamination process begins with rolls of different film resins, which are unwound, heated and pressed together with heavy duty rollers. The combination of the pressure, heat and sometimes an adhesive layer causes the film to bond together as one. In coextrusion, separate extruders are used to produce layers of different polymers. The layers are heated, combined in liquid form in the same extrusion die and forced together through the die's exit slot, thus becoming one.<sup>21</sup>

From a processor's perspective, the problems presented by lamination are much more difficult to deal with

than those presented by co-extrusion. That is because co-extrusion typically involves similar resin types, such as those in the polyolefin family, which are more compatible in the recycling process. Lamination, however, often involves less compatible films or entirely different materials, such as aluminum foil and paper. Obviously, trying to make a recycled plastic product out of paper and aluminum is extremely difficult.

Unfortunately, cross-resin contamination from multi-layer films is difficult to avoid, particularly in recycling

programs that target food packaging film or film from residential recycling programs. But, while multilayer film causes problems for recycling, it is important to keep in mind that it is essential for some original package performance requirements. As mentioned earlier in this report, there is no single resin that could meet the performance requirements of a boil-in-bag pouch; instead, it needs three materials—PET, PE and an adhesive layer—to function properly.

Tapes and Labels: Tapes and labels present chal-

#### SPARTAN STORES' STRETCH WRAP RECYCLING PROGRAM

Spartan Stores, Inc., is the seventh largest wholesaler of grocery and related products in the country. It comprises more than 525 affiliated retail stores serving Michigan, Ohio, Indiana, Kentucky, Pennsylvania, Tennessee and West Virginia. Spartan offers a number of services to its affiliated stores, including but not limited to, recycling services for corrugated cardboard (OCC), plastic grocery sacks, stretch wrap and PS foam.

Although there are a number of smaller chains within Spartan that have their own distribution centers for certain products, Spartan Stores has three major warehouse facilities located in Michigan: one in Grand Rapids, a second in Plymouth and a third in Charlotte, which is called the Support Services and Reclamation Center (SSRC). The latter is the heart of Spartan's recycling operation because it is where most recyclable materials are received and processed.

About 85 percent of the stretch wrap recycled by Spartan Stores is generated and collected in its W/DCs. Virtually all of the items that come into the W/DCs are secured to shipping pallets with LDPE stretch wrap. As the incoming pallet loads are broken down for distribution to retail stores, the stretch wrap is stripped off and placed in collection bins (usually gaylord boxes) located throughout the building. Employees are urged to remove any noticeable tape before placing the film in the collection bins. Once the bins are full, they are then trucked to the SSRC for processing.

The remaining 15 percent of the stretch wrap recycled by Spartan Stores comes from retail stores. (This is where Spartan has seen the most growth in its program because more and more stores have decided to participate in the recycling program. In 1992, retail stores only contributed about 5 percent of the total amount of stretch wrap recycled, whereas today they contribute about 15 percent.) In most instances, the stores that participate in the stretch wrap recycling program place the stretch wrap taken from incoming pallets into large plastic bags. The bags are then placed in trailers with other recyclables and sent to the SSRC for processing.

Once the bins and bags of stretch wrap arrive at the SSRC, workers remove the stretch wrap and quickly inspect it. Any remaining tape is detached at that time and the clean film is sent to a baler for densification. The baled film is shipped to Trex, Inc., in Winchester, Virginia, where it is processed and used to make plastic lumber. Spartan also ships its baled grocery sacks to Trex for recycling. (The convenience of using the same market for both stretch wrap and grocery sacks is one of the reasons that Spartan switched to Trex from previous markets.)

Recently, Spartan Stores identified a market in the Grand Rapids area—called Ecologix—that accepts stretch wrap, plastic grocery sacks and PS. As a result of having that local market, Spartan decided that it would back-haul all of the material collected from individual retail stores on the west side of the state to the Grand Rapids W/DC and send it directly to Ecologix for recycling instead of hauling it to Charlotte (which is in the central part of the state). Since it costs about \$200 to ship from Grand Rapids to Charlotte, the availability of a local market helped Spartan significantly reduce the transportation costs associated with its overall recycling program, although the stretch wrap collected by the Grand Rapids W/DC is still shipped to the SSRC in Charlotte. (For more information, contact Spartan Food Stores at 517/543-5972.)

## FILM RECYCLING AT POSTAL AND DISTRIBUTION CENTERS

One place where film recycling programs are starting to come on line is at postal and distribution centers (P/DCs). The U.S. P/DC located in Dulles, Virginia, is one example of a facility that currently is in the process of designing a film recycling program that will target both stretch and shrink wrap. The Dulles P/DC, which has a strong history of recycling paper and corrugated cardboard, looked at its remaining waste stream and identified plastic film as the next logical recycling target given its volume, consistency in supply, potential value and potential marketability.

How does a P/DC generate film? It comes into the facility in a variety of ways: stretch film comes in on pallets where it is used to secure mail to shipping containers, in the form of one-time-use mail bags (for less than pallet amounts of mail) and on cardboard trays (used for shipping letters and flat 8 1/2-inch x 11-inch mail). Shrink wrap comes primarily in the form of mailers or bundling material used to ship and protect things like magazines and newspapers.

Although the Dulles facility has not yet officially quantified the amount of film that it is generating, it knows that the total has grown significantly in recent years. That is because of a major change in the postal industry, which lowered the required minimum weight of wrapped mail pallets from 500 to 250 pounds. That means that there are now more commercial mailers that can palletize their mail and with more pallets coming into the P/DC, there is also more stretch wrap.

Since it is in the early stages of designing its program, the Dulles P/DC has not yet established a collection system. It is, however, ideally suited for a back-haul arrangement because the P/DC has 50 satellite offices in the area to and from which trucks are regularly running. Each of these facilities—from the small neighborhood post office to the larger urban post office—generates the same kind of material, meaning that the P/DC could easily act as a central consolidation and shipping point for significant amounts of stretch and shrink wrap.

In theory, each facility will locate some kind of collection receptacle near where the pallets are unwrapped, the one-time-use bags are emptied and the bundling is removed. The collection bins will be moved to a central storage area in each post office when they are full and periodically loaded onto trailers that are dropping off mail from the P/DC. Back at the P/DC, the film will be inspected and densified in some fashion for shipment to market (along with the material generated at the P/DC itself). The Dulles P/DC currently is in the process of identifying markets that will accept both stretch and shrink wrap mixed together to reduce any sorting requirements at its facilities. It also would like to identify a market (either the same market or one nearby) that can accept the plastic strapping that is also generated in relatively large quantities and could be shipped on the same vehicle. (For more information on the planning process at Dulles, call 703/406-6359.)

Challenges in film recycling mostly because they introduce different materials into the recycling system. For example, tapes can be made with different plastic resins or with other materials and they may have pigments, making them incompatible with the primary resin used in the film. Labels are problematic because they are commonly made of paper, which clearly is not compatible with plastic because it is an entirely different material. Most processors ask their suppliers to limit the use of tapes and labels for these reasons.

**Adhesives:** Adhesives show up in a variety of forms. They are commonly used in the lamination process to bond two types of film or two types of material together. They also are used on the backs of tapes and

labels that are secured to film packaging.

Adhesives cause problems in film recycling in two ways. First, they are designed to be used in the manufacturing process at certain temperatures that may be above those of some films (like PE) and below those of others (like PP). Therefore, they could show up as unmelted particles and/or gels in the recycled product. Second, if the adhesives do not melt fully, the remaining particles are small enough to pass through the filtering screens used in extruders. If the processor is making a recycled film product, the adhesive particulates or gels will appear as sand or tiny bumps, which may adversely affect print quality.

Some film recycling systems can partially remove

### GIANT FOOD STORES' GROCERY SACK RECYCLING PROGRAM

In 1991, Giant Food Stores started a grocery sack recycling program. The company did it for two reasons. First, Giant recognized that recycling, as an environmental movement, was gaining momentum and its customers were looking for opportunities to participate. Second, Mobil Chemical Company, a potential market for Giant's grocery sacks, offered to help the stores set up a recycling program. (As a growing consumer of recovered film, Mobil believed it was important to its own success to (1) identify potential feed streams and (2) work closely with suppliers to develop strong collection programs that generate high-quality materials.)

After talking with Mobil and looking at internal issues, Giant decided that it would, indeed, begin collecting grocery sacks at its stores. Collection bins were placed at each of its 75 stores located throughout Pennsylvania, Maryland, Virginia and West Virginia. Each bin had a sign near it explaining that only bags that were originally provided by Giant should be placed in the receptacles. (That way they could help ensure that only LDPE bags were included. At a later date, they also started accepting clear newspaper bags.) The signs also asked consumers to remove any contaminants from the bags before depositing them in the bins.

Store employees were then trained to monitor the bins on a regular basis and once full, take them to a central storage area where the bags could be emptied into larger bins, gaylords or plastic bags—whatever each store had available for containment. When a significant amount of material had accumulated, the full containers were shipped to Giant's W/DC in Carlisle, Pennsylvania, using a back-haul approach. There, employees remove the sacks from the containers and put them into the on-site baler. (No inspection is conducted by employees at the W/DC.) The bales of sacks are then loaded onto a tractor trailer, which, when full, transports the bales to the Trex recycling facility located in Winchester, Virginia. (Trex recently became a company independent of Mobil Chemical, which was Giant's original market.) Giant Food Stores' representatives estimate that they get back for recycling about 25 percent of the bags they give out.

At Trex, the grocery sacks are used along with stretch wrap as a feedstock to manufacture a plastic lumber product. The lumber is a nonstructural wood polymer composite that, through a proprietary process, is made with a mixture of post-consumer LDPE and recycled wood fibers. Trex uses an estimated 5 million pounds of recovered film each month in its manufacturing process. (For more information on Giant's program, call 717/249-4000. For information on Trex's program, call 800/289-8739.)

adhesives through washing and abrasion, but, if not removed, their presence will reduce the value of the recovered resin. There also has been some experimentation with water-based adhesives, but their use has not yet been embraced by the packaging community because of performance limitations.

**Dyes, Pigments and Printing:** Dyes, pigments and printing present the same challenges for film recycling as they do for recycling rigid bottles and containers—once they are in plastic they cannot be removed. Therefore, the very presence of color limits the applications in which recycled film can be used. It must be put back into products where color is not important, where dye can be used to mask the recycled material, or where the product is co-extruded so the recycled layer is obscured between two virgin layers.

Printing presents particular challenges in film recycling because layers of dense and vivid colors are often screened one over another, which dramatically

increases the ratio of ink to material. (Think of a multicolor logo on a retail bag, which required screens of four or more different colors.) Since dyes, pigments and printing of any kind limit the uses for recycled film, they also limit the revenue that can be received through recycling.

**Moisture:** Moisture is not a problem in systems that wash recovered film. It is, however, a problem in dry processing systems for a number of reasons. First, moisture in film that is stored for long periods becomes a breeding ground for bacteria, mold and unpleasant smells, all of which decrease the value of the material and make processing unpleasant if not more difficult. Second, moisture can present handling problems. When bales are broken open and moisture spills on the floor of the processing facility, it becomes a safety hazard. Third, moisture is not plastic film, and because markets pay by weight, they do not want to pay for water, which adds considerably to the weight of the material.

**Foreign Materials:** Anything that is not film presents challenges for film recyclers. Metal can cause serious problems with grinding equipment and clog extruder screens. Paper in particulate form can make its way through the openings in extruder screens and end up as small lumps in recycled film. Rigid plastics are a contaminant because they are in a form that is not easily handled by film recycling equipment and they increase the risk for cross-resin contamination. Dirt, stones and gravel, which are a particular problem in agricultural film, present difficulties for recyclers because they wreak havoc with the blades of the grinder, dulling them to the point where they can no longer be used (which reduces the efficiency of the recycling system and requires more frequent replacement of the blades at considerable cost). Degradation resulting from extended exposure to ultraviolet light is also a problem when recycling films used in outdoor applications, as is the presence of any other material or substance that is not film. For these reasons, contaminants need to be removed in order for film recycling to succeed.

**Cost:** All of the challenges mentioned above directly affect the cost of recycling film and, thus, whether it is economically viable to reclaim it. For example, if it costs more to collect and upgrade the material than the film can bring on the open market, then recycling may not make sense.

Where film recycling makes the most sense is in instances where large quantities of like film are generated, where contamination levels are low and where there is an economic incentive to recycle—that is, where significant quantities of film can be diverted from landfills and, therefore, help the collector avoid tipping fees.

Again, these factors seem to converge most often at large W/DCs. For example, Spartan Food Stores in Michigan started recycling stretch film in the early 1990s. When calculating its program costs, Spartan found that it did cost more to collect and handle its stretch wrap than it received in revenue from its market. However, it also found that it was accruing signif-

#### MERITER HOSPITAL RECYCLES PP STERILIZATION WRAP

Meriter Hospital is a not-for-profit, locally owned and directed community hospital in Madison, Wisconsin. In 1990, it appointed a 15-member interdepartmental Waste Management Team to oversee Meriter's existing recycling programs and identify new opportunities to divert waste from area landfills. One material the committee identified as a potential target for recycling was the polypropylene sterilization wrap that is used to cover surgical instruments. Meriter approached Kimberly-Clark, the manufacturer of the wrap, to determine whether and how the material could be recycled.

With assistance from Hospital Waste Management, Inc. and Kimberly-Clark, Meriter set up an in-house collection program for the material. It works as follows: First, linen carts or hampers are placed in every operating room (OR). As the staff prepares for an operation, the sterilization wrap is removed from the surgical instruments and placed into the bags in the carts. When the bags are full, employees take them out of the carts and store them in cages in an OR storage area. Then, when the cages are full, the staff rolls them to a central storage area where they are held until enough material is available to make a bale. The hospital uses its corrugated cardboard baler (which it had purchased previously for recycling old corrugated cardboard) to densify the sterilization wrap prior to shipment. Contacts at Meriter indicate that they make about two 600-pound bales per month (although the baler is capable of making bales of up to 1,100 pounds).

When the program first started, Meriter transported the bales of sterilization wrap, along with its other recyclables, to a local processor that stored them until five to six bales had accumulated. At that time, Kimberly-Clark would send a truck that was dropping off new supplies at the hospital over to the processor to pick up the stored bales (i.e., the back-haul approach). The material was then transported to a recycler near Kimberly-Clark in Georgia that used the recycled material to manufacture such products as fence posts, construction material for marine applications and handicapped parking space bumpers. Now, however, Meriter has a new contract with a local hauler to deliver the recovered wrap to an in-state reclaimer.

In 1994, Meriter Hospital diverted more than seven tons of sterilization wrap from local landfills and became the first hospital to implement the "Wrap Recycling Program" in conjunction with Kimberly-Clark. Today, approximately 49 other hospitals across the country have implemented similar programs. (For more information, contact Meriter Hospital at 608/267-6124.)

ificant savings by not having to haul and dispose of the large quantities of stretch wrap. Therefore, with the money it got from its market plus the money it saved in landfilling minus the cost of collecting and handling, Spartan was actually coming out ahead on its stretch wrap recycling program.

When communities, organizations and/or businesses weigh the pros and cons of recycling plastic film, they must take all of these challenges into consideration.

They must understand film recycling processes and select the one that makes the most sense given the type and quality of potential feedstocks and the end product that will be manufactured. They also must invest in equipment that will enable them to process and upgrade the material so that it is suitable for use in recycled products. And, they must find ways to address the challenges in film recycling by generating a sufficient volume of material, creating an infrastruc-

---

## ADDITIONAL SOURCES OF INFORMATION

In addition to this report, the American Plastics Council currently has three other documents that contain valuable information on film and film recycling: (1) "Plastic Packaging ... Opportunities and Challenges" includes much of the technical information about film packaging found in this report; (2) "Use and Disposal of Plastics in Agriculture," describes and quantifies the amount of film used in agricultural applications and discusses current

recycling activities and (3) "Stretch Wrap Recycling: A How-To Guide," walks through the steps necessary to implement a film collection program in W/DCs and grocery stores. All three of these reports can be downloaded from <http://www.plastics.org>. In addition, the line has a listing of companies across the country that accept film for recycling.

---

<sup>1</sup> One mil is equivalent to one one-thousandth of an inch.

<sup>2</sup> Robert Testin and Peter Vergano, "Plastic Packaging ... Opportunities and Challenges," 1992, pp. 12-13.

<sup>3</sup> Testin and Vergano, p. 34.

<sup>4</sup> Flexible Packaging Association, "The Benefits of Flexible Packaging," p. 3.

<sup>5</sup> Ibid.

<sup>6</sup> Data provided by DuPont to the American Plastics Council.

<sup>7</sup> Testin and Vergano, p. 20.

<sup>8</sup> Testin and Vergano, p. 37.

<sup>9</sup> Testin and Vergano, p. 35.

<sup>10</sup> American Plastics Council, "Plastics in Perspective."

<sup>11</sup> Testin and Vergano, p. 44.

<sup>12</sup> These data were provided by Ben & Jerry's to the American Plastics Council.

<sup>13</sup> The Procter and Gamble Company.

<sup>14</sup> Franklin Associates' numbers vary from those cited earlier in the report because Franklin bases its estimates on sales data provided by Modern Plastics, whereas the data reported earlier are provided by The Society of the Plastics Industry, Inc. (SPI), both of which calculate their numbers differently. The Franklin numbers are used at this point in the document because they are the best available data dealing specifically with waste generation. They also show the sectors in which film is generated and how much is landfilled and combusted. Similar data are not available from SPI.

<sup>15</sup> "Characterization of Municipal Solid Waste in the United States: 1995 Update," U.S. Environmental Protection Agency.

<sup>16</sup> The League of Women Voters, "The Plastic Waste Primer: A Handbook for Citizens," p. 103.

<sup>17</sup> Dr. J. Winston Porter, "Plastics and Waste-to-Energy Combustion;" The League of Women Voters, "Plastic Waste Primer: A Handbook for Citizens," p. 98.

<sup>18</sup> American Society of Mechanical Engineers, "The Relationship Between Chlorine in Waste Streams and Dioxin Emissions from Waste Combustor Stacks," 1995, CRTD Vol. 36.

<sup>19</sup> Association of Plastics Manufacturers in Europe, "Energy Recovery Through Co-combustion of Mixed Plastics Waste," 1994.

<sup>20</sup> D. A. Kahl Consulting, memo on plastics densification technology, 1995.

<sup>21</sup> Testin and Vergano, pp. 22-24.