PLASTICS MARKET WATCH

PLASTIC BOTTLES TODAY

INNOVATING TO REACH TODAY'S CONSUMER

PLASTICS INDUSTRY ASSOCIATION

BETTER INDUSTRY. BETTER WORLD.

February 2017

The Plastics Industry Association (PLASTICS) sends special thanks to the Brand Owners, Processors and Equipment Councils, and Rigid Plastics Packaging Group (RPPG) for their guidance and input on this Bottling Plastics Market Watch Report.

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Plastics Market Watch

Plastic Bottles Today

Innovating to Reach Today's Consumer

A series examining the business of plastics, including demographics, economics, policy developments and technological trends in specific plastics end markets.

Contents

Forward

The Plastics Industry Association's (PLASTICS') Plastics Market Watch reports provide forward-looking data and insights on key plastics industry end markets. The series examines the business of plastics, including demographics, economics, policy developments and technological improvements for markets including automotive and transportation, healthcare and medical devices, packaging, building and construction, automotive recycling, bioplastics and consumer electronics.

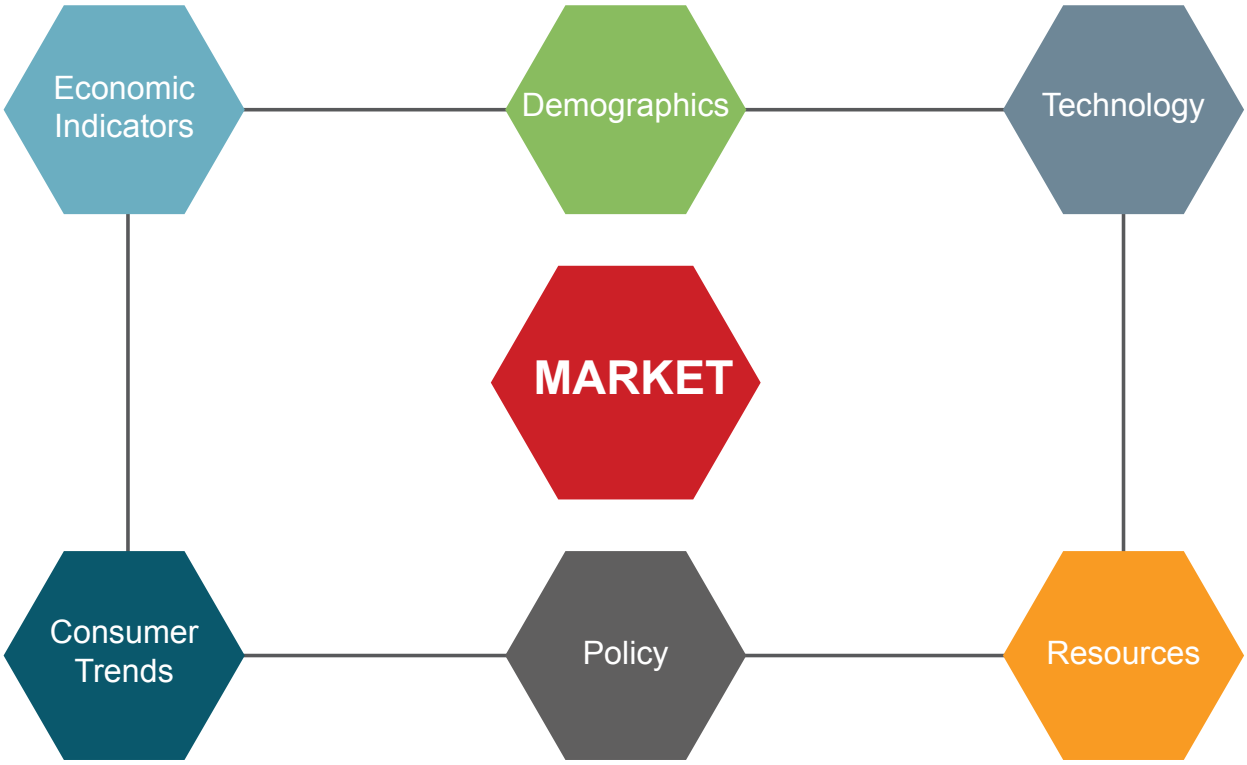
Given the role that plastics play in today's modern society, Plastics Market Watch reports offer a holistic picture of our technology—from beginning-of-life resins and polymers to end-of-life management and recycling efforts. Our industry and members have a responsibility to explain the whole picture of plastics and our industry; too often the role of plastics is overshadowed by other technologies or misunderstood. For the average consumer—like a car buyer or a homebuyer—plastics' contribution to their purchase is likely underestimated, but plastics are essential for a vehicle's performance, gas mileage and styling, and a home's insulation, wiring and pipes. The role of plastics within the consumer technology space is the same story: other parts of a television, drone or gaming system attract the attention of users, but plastics are essential to their design, function and performance.

PLASTICS wants to explain the material's role for our society as well as provide our members with forward-looking analysis of our key end markets in terms of economic and demographic analytics that chart out our future. While a consumer may visualize one kind of plastic bottle, such as a water bottle, the fact is plastic bottles encompass a wide range of plastics, shapes and designs, contents and applications. This Plastics Market Watch report will look at the reason for plastic bottling's growth and expansion, including the diversity of plastics used in bottling, cost-effectiveness and savings in materials, safety, storage and shipping, and the effectiveness of plastics' ability to protect its contents. Innovation in plastic bottling—from polymers to molding equipment—advances at a significant pace, while the segment leads in recycling initiatives and success.

Plastics Market Watch Reports Available:

- Automotive and Transportation
- Healthcare and Medical Devices
- Packaging
- Building and Construction
- Automotive Recycling
- Bioplastics
- Consumer Technology

Chart 1
Key Drivers for End Markets



PLASTICS intends for these Plastics Market Watch reports on key industry end markets to be a component of member companies' strategic planning and intelligence gathering process. We welcome feedback and questions from our members and look forward to presenting our reports and insights at future PLASTICS gatherings and meetings.

PLASTICS wants to explain plastics' role for our society as well as provide our members with forward-looking analysis of our key markets in terms of economic and demographic analytics that chart out our future. Consumer electronics exemplifies the challenge our industry faces in articulating our contributions to a sector; at first blush, consumer electronics is a Silicon Valley-centric industry defined by the Internet, software and applications, chips and advanced technology that is transforming our economic and social landscapes. But on closer analysis, plastic is a key contributor to the consumer electronics sector because of its protective, light weighting properties, insulation and wiring qualities, and the flexible, safe design properties that are increasingly being used in products that consumers hold and use every hour of the day for their business, communication, health and entertainment.

This Plastics Market Watch report will offer members a current and forward-looking analysis of the Consumer Electronics sector in terms of economic, demographic and technology trends in the sector—as well as public policy issues that are shaping the future of the sector.

PLASTICS wants these Plastics Market Watch reports on key industry sectors to be a component of member companies' strategic planning and intelligence gathering process. We welcome feedback and questions from members and look forward to presenting our papers and insights at future PLASTICS gatherings and meetings.

Introduction: Plastic Bottles Today—Innovating to Reach Today's Consumer

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Plastic bottles have specific manufacturing and performance advantages over other packaging materials like aluminum, steel and glass that have helped plastics expand their market share of packaging materials. But with the growth of plastic bottling there is a heightened awareness of end-of-life (EOL) issues regarding their recycling and disposal. The plastics industry—and the entire value chain—has responded with sustainability efforts and educational endeavors. Yet plastics litter—whether a recycled bale or a bottle floating on a waterway—is a visible and galvanizing image that demonstrate the extremes of how plastics are managed after they are used.

Without question, plastic bottles have come a long way since their first commercial uses in the late 1940's. The introduction of high-density polyethylene (HDPE) and polyethylene terephthalate (PET) polymers expanded plastic bottling applications. Plastics then surpassed glass as the go-to packaging choice for a wide array of products and brands.

> "Plastics then surpassed glass as the go-to packaging choice for a wide array of products and brands."

The importance of plastic bottles to PLASTICS' membership—and the overall stakeholders like consumers, brands, policymakers and NGOs—is unquestioned. Bottling ranks high in PLASTICS' data on the plastics industry's output with only packaging film and sheet/plastics (except packaging) being higher in terms of employment numbers, value of industrial shipments and capital expenditures.

PLASTICS' premier event NPE2018 will include a new feature, The Bottle Zone, an end-to-end exhibit on the NPE show floor for companies and brand owners in the beverage and bottling industries. The Bottle Zone will spotlight innovations, technologies and solutions for the beverage bottling and PET markets. PLASTICS President and CEO William R. Carteaux said, "Plastics are integral to the bottling world's ongoing success and continued innovation. This vital industry segment hasn't had a singular event and exposition where solutions providers and industry professionals can gather to exchange new ideas, technologies and answers to the unique challenges facing the beverage, bottling and PET market. The Bottle Zone at NPE2018 will change that. This is where every company in the bottling supply chain can connect with market-leading equipment and solution providers and access the combined expertise they need to move their businesses forward."

In addition to exhibits, The Bottle Zone will feature an education program on the latest technological advancements, market insights and business strategies in the bottling industry, among other subjects.

For brands using plastic bottles, the benefits plastics packaging provides are measurable, but society has equally benefited from plastic bottles. The Ellen MacArthur Foundation reported last year in its "The New Plastics Economy" that plastics and plastic packaging are an integral part of the global economy and "imagining a world without plastics is nearly impossible." Today's food production supply chain depends upon plastic bottling and packaging.

However, the Ellen MacArthur Foundation reported that while plastics are "the workhorse material of the modern economy," the material has drawbacks. According to the MacArthur Foundation, 32 percent of plastic packaging escapes collection systems altogether (predominantly in Southeast Asia), generating significant economic costs (and losses) while negatively impacting natural systems like the oceans and contributing to unsightly litter that can negatively affect tourism. But rather than condemn plastics, the Foundation calls for collaborative effort across the value chain for increased coordination, innovation and the introduction of new packaging materials, and thousands of small-scale local efforts to improve collection, sorting and recycling efforts around the globe.

PLASTICS and its members are at the center of this coordinated effort and commitment: advancing new polymers and technologies, improving performance and making clear commitments to recycling. Educational efforts on recycling are ongoing and improving, but the greatest change needed is the mindset of all consumers and stakeholders that a plastic bottle or container has real economic value through recycling and the potential to become a new bottle, new product and consumer or societal benefit. This is why PLASTICS supports efforts like The Recycling Partnership that is working to expand access to recycling opportunities for bottles and many other forms of packaging and improve the quality of the material returned to the recycling system.

The Bottling Plastics Market Watch is a resource showcasing the strength of the bottling end market and the plastics industry's focus and commitment to bottling. This report provides an opportunity to advance the conversation in and out of the industry leading up to NPE2018. In the coming months, PLASTICS will help to best position the industry in meeting the needs of bottling brands and their consumers around the world while addressing the challenges that are keeping us from advancing recovery.

Role of Plastics in Bottling

Role of Plastics in Bottling

Plastics in Everyday Containers

Plastic bottles and jars represent approximately 75 percent of all plastic containers, by weight. While PET and high-density polyethylene (HDPE) represent approximately 86 percent of the plastic container market and are able to serve the bottling needs of most products on the market today, other types of plastics—including bioplastics and recycled plastics—are used for a wide range of bottling and packaging needs in a variety of industries, and are recyclable:

Polyethylene Terephthalate (PET, PETE, PETG or polyester) is commonly used for carbonated beverages, water bottles and many food products like peanut butter and jelly jars, and cooking oils. PET provides strong impact resistance and tensile strength. PETG, one form of PET, offers greater design freedoms than standard PETE, such as the ability to add handles to orange juice jugs. PET packaging has excellent barrier properties and also offers crystal clear transparency so consumers can see the product.

High Density Polyethylene (HDPE) is used for kitchen, bath and laundry bottles, as well as other consumer goods. HDPE is economical and impact resistant, and provides a good moisture barrier. HDPE is compatible with a wide range of products including acids and caustics but is not compatible with solvents. It can be used for bottle caps, milk jugs, grocery bags, shampoo bottles, yogurt tubs, detergent bottles, hard hats, backpack frames, hula hoops, etc. HDPE is naturally translucent and flexible. The addition of color will make HDPE opaque, but not glossy.

Polyvinyl Chloride (PVC) is naturally clear plastic that is extremely resistant to oils and chemicals and most often used in the toiletry and cosmetic market. It provides an excellent barrier to most gases and its drop impact resistance is also very good.

Low Density Polyethylene (LDPE) is similar to HDPE in composition, but is less rigid and less chemically resistant than HDPE. LDPE is used primarily for squeeze bottles (ketchup/mustard) as well as food storage containers, film/shrink wrap, and bags (produce, grocery, trash, dry cleaning and bread). LDPE is a versatile and impact-resistant and reusable plastic that is generally more expensive than HDPE. Despite specific initiatives to increase recycling, its recycling rate is less that PET and HDPE.

Polypropylene (PP) is used primarily for jars, medicine bottles and closures, and provides a rigid package with excellent moisture barrier. PP is durable and versatile.

Polystyrene (PS) offers excellent clarity and stiffness—glass-like quality—at an economical cost. It is commonly used with dry products including vitamins, petroleum jellies and spices.

Other Resins, like polycarbonate (PC), are in plastics bottles. PC is a clear plastics used to make stiff, reusable personal water bottles. PC is recycled with a variety of plastic resins not identified by codes.

Overview of the Resin Identification Codes

The Resin Identification Code (RIC) system was developed and introduced by PLASTICS, then Society of the Plastics Industry, in 1988 to identify the plastic resin used in a manufactured article. Contrary to popular belief, the RICs are not recycling codes; their use does not imply that the article is recyclable. Today, the RIC codes are under the direction of ASTM International, and are a vital tool and information source for all players in the plastics industry.

> "Contrary to popular belief, the RICs are not recycling codes."

PLASTICS participates in ASTM International's efforts to develop a new standard that would expand the current RIC system; the changes reflect, in part, the growth and expanded usage of plastics in today's modern society. In 2013, ASTM issued a new standard, ASTM D7611—Standard Practice for Coding Plastic Manufactured Articles for Resin Identification, which includes the following requirements:

- The Code is to be molded, formed or imprinted on the manufactured article as well as be clear and legible.
- The Code shall consist of a number placed within a solid equilateral triangle and letters placed below the triangulated as shown in Table 1 as per the size requirements noted in the standard.
- The Code shall be placed in an inconspicuous location on the manufactured article, such as the bottom or back, where it will not be obvious to the consumer at the point of purchase so it does not influence the consumer's buying decision.

Since its development, the RIC has been codified in a majority of U.S. states. However, companies marking their products should be aware that some of these state laws, including California, specifically reference the old design of the RIC, calling for the "chasing arrows". In order to be in compliance with these states, companies should consider whether it is best to use the old version of the RIC (see Table 2 below), or the new version of the RIC (Table 1).

Table 1

Resin Identification Codes (RICs)

Resin Identification Number	Resin	Resin Identification Code Option A	Resin Identification Code Option B
1	Poly (ethylene terephthalate)	1 PETE	01 PET
2	High density polyethylene	2 HDPE	02 PE-HD
3	Poly (vinyl chloride)	3 V	03 PVC
4	Low density polyethylene	4 LDPE	04 PE-LD
5	Polypropylene	5 PP	05 PP
6	Polystyrene	6 PS	06 PS
7	Other resins	7 OTHER	07 O

Table 2

Old Version of the RIC

Resin Identification Number	Resin	Resin Identification Code (Both Options Permitted)
1	Poly (ethylene terephthalate)	1 PETE 01 PET
2	High density polyethylene	2 HDPE 02 PE-HD
3	Poly (vinyl chloride)	3 V 03 PVC
4	Low density polyethylene	4 LDPE 04 PE-LD
5	Polypropylene	5 PP 05 PP
6	Polystyrene	6 PS 06 PS
7	Other resins	7 OTHER 07 O

More information about the history and purpose of the RIC can be found on Wikipedia: **https://en.wikipedia.org/wiki/Resin_identification_code**

Growth of Plastics Bottling

Growth of Plastics Bottling

The first objective of bottling—and all packaging—is to deliver a safe product to all consumers. Instead of alternate materials, many brand owners have turned to plastics to minimize waste and establish a carbon neutral footprint.

> "Many brand owners have turned to plastics to minimize waste and establish a carbon neutral footprint."

Joel Morales, IHS chemical director at Polyolefins North America, said plastic packaging provides numerous advantages over conventional materials, "most notably safety versus glass products, light weight packaging versus glass and metal, and attractive and unique designs for brand awareness."

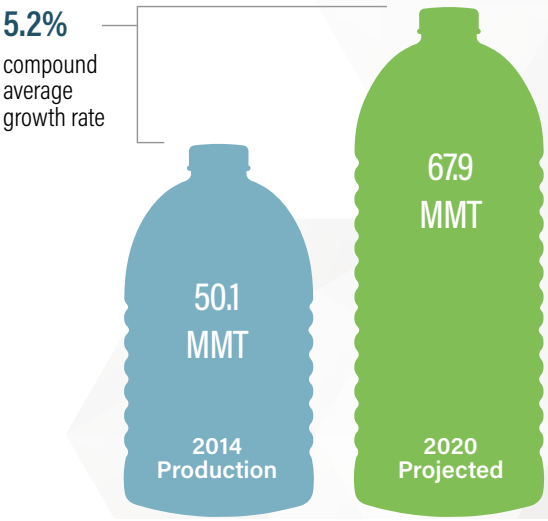
"The versatility of plastics, particularly with rigid plastics is a clear advantage," said PLASTICS' Senior Director of Industry Affairs George Southworth. "Different properties of plastic resins offer great design flexibility—from water bottles to detergent bottles. The lightweight nature of plastics makes it very attractive to ship, transport and store, and the amount of energy required to produce plastics compared to other materials is also very advantageous."

According to Research and Markets, the global production of plastic containers in 2014 was 50.1 Million Metric Tons (MMT) and is estimated to reach 67.9 MMT by 2020; a compound average growth rate of 5.2 percent. In terms of revenue, the market was worth $273.15 billion in 2014 and will reach $388.35 billion in 2020 at a growth rate of 6 percent.

The beverage sector currently represents the largest market share of plastic bottles, with 40 to 45 percent in the developed regions in North America and Europe, according to Research and Markets 2014 data. Research and Markets also reported that plastics comprise 22 and 30 percent of the pharmaceutical and consumer packaged goods (CPG) sectors, respectively. The health care and bottled water sectors, however, are increasing their usage of plastics; the food and beverage industry constitutes around 50-to-55 percent of the total plastic bottles usage globally.

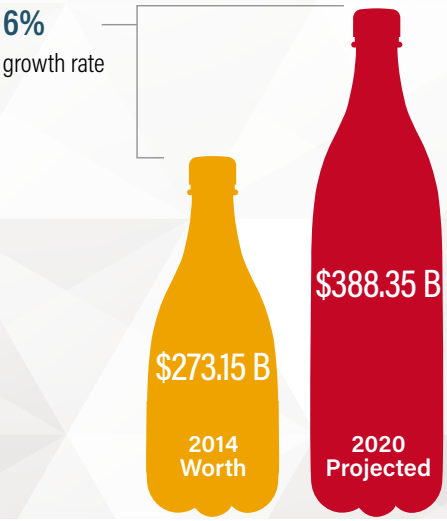
Global Production of Plastic Containers

MMT: Million Metric Tons

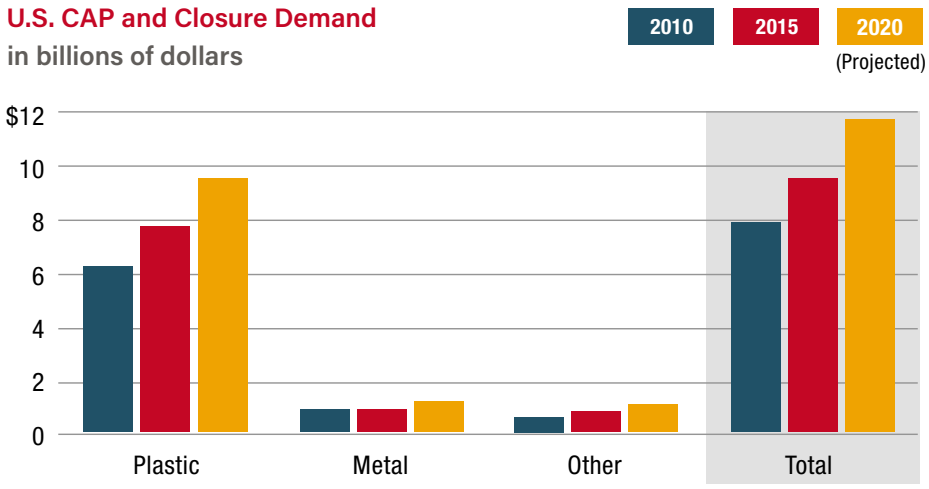


Plastic Containers Market Worth

B: Billion



U.S. CAP and Closure Demand
in billions of dollars



Growth of plastic in packaging can be seen in the demand for caps and closures for plastic, metal and other containers.

> "Many so-called 'packages' are essential drug delivery systems and are part of the safety and reliability of pharmaceuticals."

> "Demand for plastic containers is predicted to rise 4.9 percent annually."

In the U.S. market, Freedonia Group, a research firm, reported that demand for plastic containers, attributed to economic comeback from the Great Recession, is predicted to rise 4.9 percent annually to $32.4 billion in 2016, consuming 14.2 billion pounds of resin. In addition, demand for caps and closures in the U.S., according to Plastic News' Plastic Caps & Closures Market Outlook, is expected to grow 4.2 percent each year to $11.8 billion in 2020.

Although pharmaceutical packaging represents a small percentage of the overall plastics bottling market, it is a growing sector in the industry and crucial for the delivery of medicines to consumers and healthcare providers around the world. According to Plastics Business, "many so-called 'packages' are essential drug delivery systems and are part of the safety and reliability of pharmaceuticals."

The global pharmaceutical market is expected to reach a value of $85 billion by 2017 according to a market report at Markets and Markets. Freedonia Group estimates the U.S. pharmaceutical packaging sector will increase 4.9 percent annually to $22.1 billion in 2018. The increased use of generic drugs is expected to be a leading market for plastics packaging, although new technology and innovations in pharmaceutical plastics packaging are being used to deliver new medicines and therapies. Biotech-based medicines and protocols delivered via syringes are also a growing sector for plastic packaging.

However, due to lightweighting efforts and design changes by brands and bottlers, the average weight per container unit continues to drop, and overall volume gains will lag behind value gains. Furthermore, moves by brands to adopt pouches and other types of flexible plastic packaging will likely impact plastic bottling, although pouches may augment the current plastic container market rather than replace the rigid containers.

According to the National Association of Container Distributors, the push for lightweight packaging from consumers and businesses is spurring the growth of polyethylene terephthalate. According to Smithers Pira, a business intelligence firm, PET's market value for packaging could reach $60 billion by 2019—up from $48.1 billion in 2014. On average, the PET packaging market will grow 4.6 percent each year as manufacturers in food and beverage, as well as health and personal care products companies, increasingly turn to the lightweight plastic known for its durability and ease of use.

> The lightweight nature of plastics makes it very attractive to ship, transport and store, and the amount of energy required to produce plastics compared to other materials is also very advantageous.

The focus on PET and its market share growth has been reflected by a number of developments and trends in how brands and products use PET. With its clarity and natural CO2 barrier properties, PET has wide applications and is easily blown into a bottle or formed into a sheet. PET properties can be enhanced with colorants, UV blockers, oxygen barriers/scavengers and other additives to develop a bottle to match with a brand's specific needs. It should be noted, however, that with each modification and additive, there may be an impact on the recycling stream.

"The pace of innovation in the plastics industry [compared to glass or metal] is remarkable as multiple avenues are underway to explore opportunities to improve on issues like shelf life and flavor performance," said Philip Berrier, senior manager of Scientific and Regulatory Affairs, Food Contact Substances at Coca-Cola North America Group.

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Innovation

Innovation

What Drives the Growth of PET Bottles?

1. Lighter Packaging

The effort for lighter packaging was one of the early developments in plastic bottles overtaking glass as the container of choice for brands. Now, manufacturers are looking to save even more by lightweighting their plastics. The benefits of lighter packaging are multiple, from lower raw polymer costs and shipping savings to reductions in energy costs and volumes in landfill wastes.

There are benefits to lightweighting, including cost savings and weight. For example, Dr Pepper estimates it has conserved more than 60 million pounds of plastics by redesigning its bottles and packaging.

Lightweighting has been a focal point of the bottled water sector. According to the International Bottled Water Association, the average weight of a 16.9 ounce PET (half-liter) plastic bottle has dropped 48 percent to 9.89 grams from 2000 to 2014. The drop in weight is the equivalent of 6.2 billion pounds of PET resin since 2000.

"We work with our customers to determine the best packaging solution for their product. Plastic allows us to provide customizable barrier properties, unique shape and design, package integrity/durability, and improved sustainability compared to other substrate options," said Robert Flores, director of sustainability at Berry Plastics. "Lightweighting, for example, has been a popular alternative for years, due to its dual benefit of enhancing sustainability and providing economic benefit. However, lightweighting is growing beyond downgauging a product design—it has evolved to tailoring manufacturing processes and materials to reduce package weight."

In addition, lightweighting is also being applied to closures and caps as innovation in resins provide lightweighting properties while still protecting the package from tampering and ensuring freshness. However, the lightweighting of caps and closures takes a back seat to performance in terms of an effective seal with the bottle that prevents spillage, leakage or spoilage.

2. Consumers Attracted to Portable, Easy to Handle Packaging

More than any other bottling material, PET provides the flexibility in design that consumers want. When choosing ketchup containers—glass vs. PET plastic—consumers like the ability to squeeze out precise amounts of ketchup, which also helps to reduce product waste.

3. Health-Conscious Decisions

Consumers switching to healthy beverages and other products (blended juices, water, etc.) are increasingly using PET bottles. One of the biggest PET bottle packaging drivers is single-serve water which increasingly displaces sodas, and is predicted to increase in sales by six percent annually.

4. Designing for Recycling

Brands and the plastics supply chain are also focusing on design improvements that will facilitate collection and recycling of PET bottles. The Association of Plastic Recyclers' (APR's) Champions for Change Program encourages consumer product, plastic package and bottle component manufacturers to work with the APR protocols to determine whether new modifications to a regularly recycled plastic package will negatively impact the recycling process prior to introducing the modification.

An item is "recyclable" per APR definition if:

- At least 60 percent of consumers or communities have access to a collection system that accepts the package.
- It is most likely sorted correctly into a market-ready bale of a particular plastic meeting industry standard specifications, through commonly used material recovery systems, including single-stream and dual stream MRFs, PRF's, systems that handle deposit system containers, grocery store rigid plastic and film collection systems.
- It can be further processed through a typical recycling process, cost effectively, into a postconsumer plastic feedstock suitable for use in identifiable new products.

Plastics Moving into Beer

Beer is an emerging market for plastics bottling. MillerCoors saw a spike in sales of its 40-ounce and 32-ounce bottles when it moved from glass to plastic containers. While only one percent of the company's total sales are made with plastic bottles (most beer is sold in glass bottles and aluminum cans), Jonah Smith, sustainability manager for policy and reporting at MillerCoors, predicts the use of PET bottles is only going to increase in the years to come.

MillerCoors believes the change in packaging has cut the products' carbon footprint by about 25 percent—and saved tens of millions of dollars in the process. Smith told *Plastics News* the transition to more plastic beer bottling would not be overnight and would be linked to recycling capabilities and technologies. "I'd say within 10 to 15 years you're going to start to see more and more of the packaging product mix switch over to more environmentally sustainable choices. Is PET going to increase? Probably. It's also going to increase as more MRFs, material recovery facilities, improve their technologies in how to best recycle PET," said Smith.

The benefits of plastic are clear for the beer bottles: They are shatterproof and significantly lighter, as a 40-ounce plastic bottle weighs one pound less than 40-ounce glass bottles. MillerCoors uses a unique and patented grip to make the bottles comfortable to hold.

MillerCoors is not the only brand to use plastic PET bottles. During the 2012 Summer Olympics in London, Heineken used its designation as the official supplier and sponsor of the games to sell its beer in recyclable PET plastic bottles, helping the London Organizing Committee to fulfill its pledge to produce the "most sustainable games ever."

Sporting arenas and venues in the U.S. working to improve their recycling rates—and increase safety for patrons—have adopted the use of plastic beer bottles in addition to using biodegradeable plastic cups.

> "MillerCoors saw a spike in sales of its 40-ounce and 32-ounce bottles when it moved from glass to plastic containers."

PepsiCo

Brands' efforts to drive innovation to appeal to consumers include a focus on packaging changes that increase sustainability, minimize environmental impacts and save money. Major brands, leveraging bottle and packaging changes across product lines, can have major impacts on the use of plastics.

PepsiCo packaging-reduction initiatives conducted in 2013 eliminated nearly 110 million pounds of packaging material from the market and reduced the company's packaging costs by more than $55 million across the brand's global food and beverage operations. The company was an early adopter of incorporating post-consumer recycled content into its polyethylene terephthalate plastic; approximately 10 percent of its soft-drink bottling containers have post-consumer recycled PET. Globally, the company continues to push the levels of recycled content in its bottles. In France, some PepsiCo bottles have up to 50 percent recycled content.

Lightweighting efforts of plastic bottles at PepsiCo have been ongoing for more than a decade. PepsiCo introduced the Aquafina Eco-Fina Bottle in 2009; at just 10.9 grams, the Eco-Fina Bottle was made with 50 percent less plastic than similar Aquafina bottles. The light, environmentally friendly bottles continue to be fully recyclable, and eliminated an estimated 75 million pounds of plastic annually.

An additional step Aquafina took with the Eco-Fina Bottle was to move the bottling production to the company's purification and filling centers, saving transportation costs. The new bottle also featured design innovations that provide a unique, "rippled web" design that attracts consumers.

"Consumer research confirms that we achieved our desired objective, which was a 'sustainable design trifecta'—a bottle that looks better, functions better and is better for the environment," said Robert Le Bras-Brown, vice president of packaging innovation and development at PepsiCo. "The new design leverages structural engineering which allows the Eco-Fina Bottle to support 50 times its weight in water while offering consumers a contemporary, attractive package that meets their needs."

The growth of plastics is evident in a number of products over the years, including PepsiCo's Gatorade.

Plastic bottles help brands connect with consumers. For example, Gatorade used a bottling redesign to create a global, archetypal shape for its sports energy drink. From its research, Gatorade determined consumers perceived the product as a piece of their sporting equipment rather than a beverage. Consumers expressed that the need to be able to hold and drink the beverage during exercise was a priority. Imagine the difficulty of holding, storing and enjoying a glass-bottled Gatorade on the sidelines of a sporting event. The flexibility of plastics bottling design afforded Gatorade the ability to create unique bottling functions and aesthetics for the brand's wide range of sizes and energy drinks.

Gatorade first transitioned to plastic from glass in 1988, and has since consistently modified its branding and function through its bottling. The packaging has been modified to fit into bicycle cages, offer squirt-nozzle functioning and easier handling.

Evolution of the Bottle

Beverage Trends for all Containers

All containers, whether plastic, glass, aluminum or pouch, are being tweaked by beverage marketers according to PMMI—The Association for Packaging and Processing Technologies. Based on PMMI's 2014 research, the container is the primary vehicle for a brand to stand out in the increasingly crowded marketplace. Brands not only use the container to differentiate themselves through graphics, but also with a wide variety of container design changes that appeal to consumers.

To Coca-Cola's Berrier, plastics continue to have its advantages. "Plastics offer better design options, and frankly, has a better life-cycle ecological story to tell in that it is so much lighter, you get fuel savings, savings in terms of freezers and refrigeration, and with recycling," he said.

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According to PMMI's study, six key trends are developing among beverage companies with respect to their packaging:

Size and Dimension Ratios: Brands are tweaking the sizes and shapes of their packages to tailor their products to consumer's consumption habits and to stand out on the shelves. Brands that use plastic bottles and cans tend to use smaller and tall, thin containers.

Openings: To enhance drinking experiences and appeal to consumers, brands are making design changes to container openings.

Resealability: Already an asset for plastic bottles, brands are also looking to make more aluminum containers resealable. The ability to reseal a beverage helps consumers manage portions and enhance convenience.

Texture and Feel: For beverage containers, the exterior feel and texture can contribute to a consumer's experience. Companies are developing unique textures—e.g., rough sandpaper, grooved edges or extra-glossy surfaces according to PMMI—so consumers can touch and feel a brand's product and differentiation.

Labels, Colors and Graphics: Brands continue to push the envelope of their packaging in terms of labels, colors and graphics. Temperature-sensitive labeling and graphics are being used, as well as labels that shift or change depending upon the angle a product is held or viewed.

Pack Sizes: Traditional packaging sizes—6, 12 or 24 packs—are being tweaked by brands to appeal to specific consumers, events and price points.

Plastic Bottle Economics

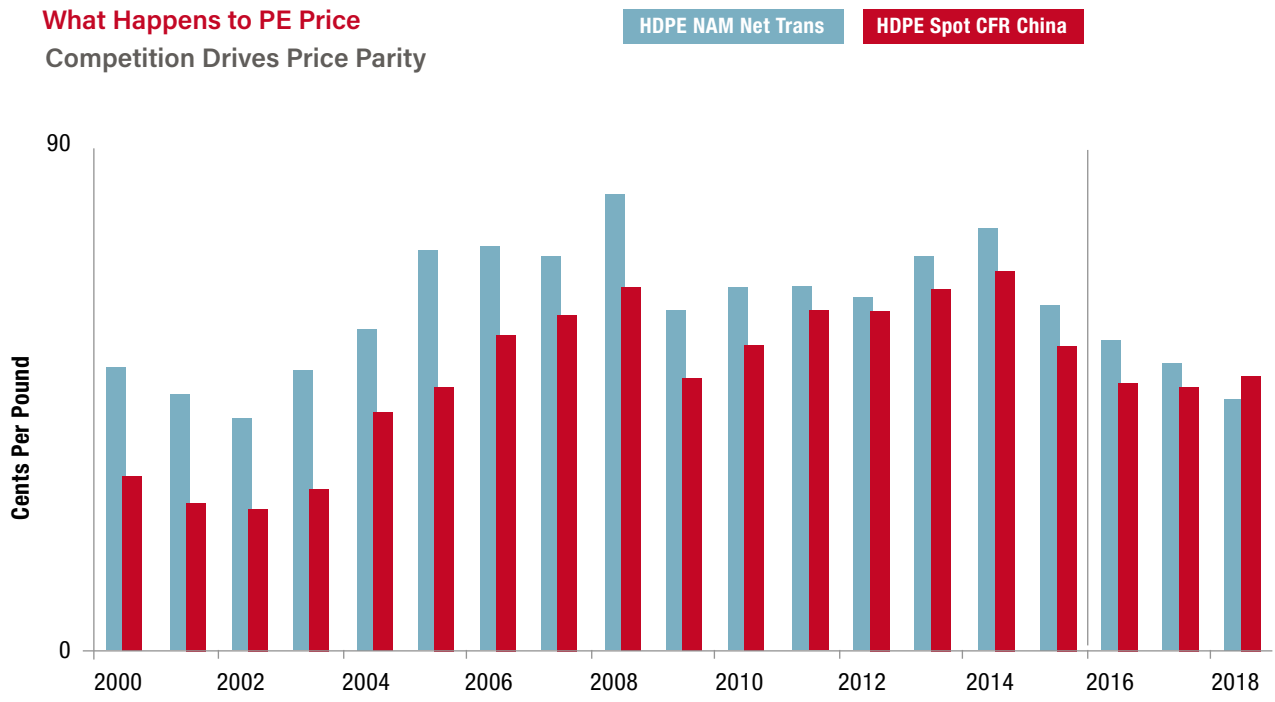
Plastic Bottle Economics

Brands turning to plastics for their bottling needs are doing so not only for the design advantages and savings in shipping costs, but also for the savings plastic polymers provide over other materials.

IHS' Morales said lower oil pricing since the fourth quarter of 2014 has reduced the overall price of plastics, helping to keep polymers competitive relative to other packaging materials like paper, tin and glass. Looking ahead at prices for bottling plastics, like PET and HDPE, Morales predicts prices in North America should continue to be competitively priced given new capacity additions coming online for both product streams.

PLASTICS' former Director of Industry Affairs David Palmer concurred and related the lower natural gas and oil prices to equipment orders. "Lower prices for oil and natural gas bodes well for the plastics industry. We have seen increases in orders and shipments of plastics machinery, predominantly in the domestic market, with the price of natural gas," he noted. In terms of equipment, injection molding orders and shipments have been particularly strong in recent years, according to Palmer.

The pricing of plastics for bottling is especially advantageous for companies in the U.S. and Middle East according to data published in *The Economist* from November 15, 2014. Raw material costs and energy prices for PET in particular are lower in North America due to the "shale-gas boom."



Source: IHS

The one sector of the plastics industry that is not enjoying the lower resin prices, however, is plastics recyclers. Recyclers have often enjoyed a cost advantage to prime material, but with prime pricing so low in recent years, that advantage has all but disappeared. In some cases, that pricing has inverted, with recycled plastics coming at a cost premium. There is a fixed cost that recyclers must bear in the process of cleaning the plastic flakes and preparing the material for remanufacturing; if that fixed cost exceeds the cost of prime, that pricing advantage will disappear.

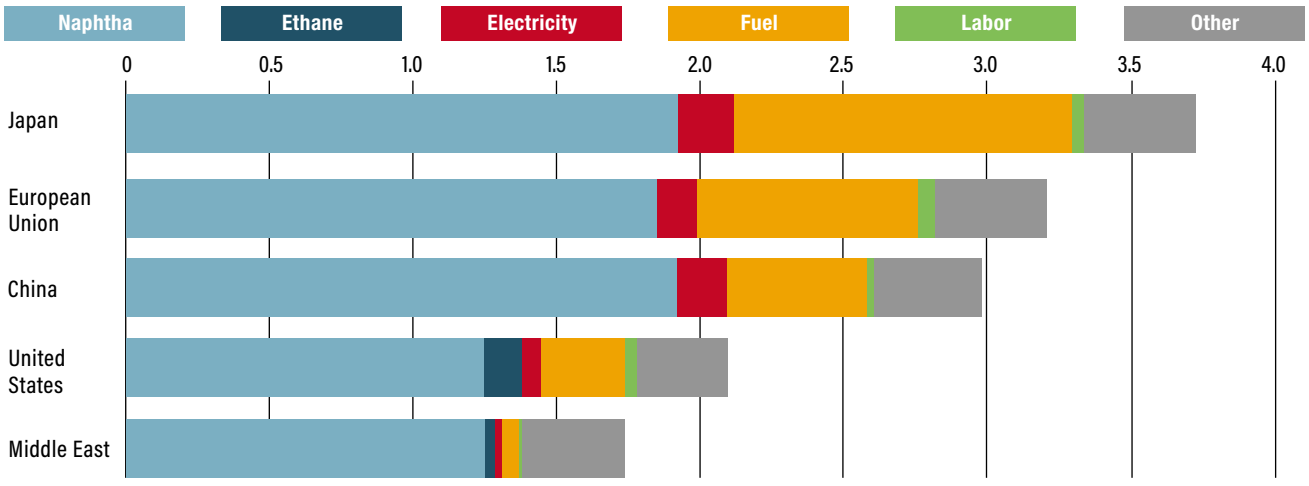
Xavier Cronin, an editor with *PetroChem Wire*, told attendees of the 2015 Plastics & Paper Recycling Conference that recycled PET pellets are selling for 10 cents more per pound than their virgin counterparts.

Because PET is derived from natural gas, PET recyclers have been hit particularly hard with reduced prime prices. In order to maintain the health of the recycling industry during periods of low prime pricing, it is important for brand owners to recognize the many other benefits of choosing to use recycled content, not just the cost advantage that they have come to rely on. Other factors, such as voluntary sustainability initiatives, green marketing, customer demands and retailer initiatives are strong drivers to weigh against material costs.

According to *Plastics News* Economics Editor Bill Wood, resin prices in 2016 are well below the levels from the same time last year, and processors in all segments of the plastics industry are passing much of these lower costs through to their customers. "In other words, processors are paying substantially less for their materials, but they are also receiving less for their products," Wood said. "This is a good situation for all concerned as long as processors are maintaining their margins."

The Price of Making a Plastic Bottle

Estimated unit cost, 2013 $ cents



Source: IEA World Energy Outlook 2014
Source: The Economist "The price of making a plastic bottle" November 15, 2014

Plastic Bottles: Soda and Water Consumption

Soda consumption is decreasing in the U.S. However, water consumption has been increasing. Both products are predominately packaged in plastic bottles. In fact, plastic bottle usage skyrocketed from 2001 to 2006 due to the sales of water. Data released in 2015 by the International Bottled Water Association (IBWA) and the Beverage Marketing Corporation (BMC) show Americans' consumption of bottled water increased by 7.9 percent and bottled water sales were up 8.9 percent compared to 2014.

Bottled water is on pace to overtake carbonated soft drinks as America's largest beverage category, by volume, by 2017, if not by the end of 2016. As for caps and closures, beverages and water bottles are expected to remain the leading end-use industry with water bottles being the fastest-growing segment of the beverage industry.

Water bottles have increased their recycled content by using rPET (recycled PET).

As the shift from soda to water progresses, the bottled water industry has worked with recycling advocates to increase recycling rates of water bottles. Currently, 37 percent of single-serve PET plastic bottled water containers are recycled—more than double the amount recycled just a decade ago. At the same time, between 2000 and 2014, the average weight of a 16.9-ounce (half-liter) PET plastic bottle declined 51 percent.

The average weight of a 16.9 ounce PET (half-liter) plastic bottle has declined 51 percent. This has resulted in a savings of 6.2 billion pounds of PET resin since 2000.

Bottling Equipment & Machinery

Bottling Equipment & Machinery

> "Companies will continue to advance the utilization of multi-layer technology which promotes the use of post-consumer resins as well as weight reducing agents."

Globally, a look at the sales of preform systems and molds is a positive indicator of market growth for bottling as developing economies and their industries and consumers turn to plastic bottling technologies. Plastic bottles are vital to the growth of their commercial and consumer sectors.

Volker Jahrling, a plastics industry expert and former MHT Director, said that approximately 200 preform systems are currently being sold every year around the world. Husky manufacturers an estimated 60 percent of these systems, and has manufacturing facilities in eight nations and services and sales offices in 40 countries. Husky has its equipment and services in more than 100 nations. The second largest preform machine manufacturer is Netstal, a Swiss company with manufacturing facilities and offices located around the world.

In addition to systems, Husky also sells molds, where it holds 50–60 percent marketshare. Other major moldmakers include Otto Manner GmbH, MHT Plastics, and other companies, mostly out of Asia.

Current generation preform molding machines cost approximately $1.6 million and have an average life of 10 years, with longer lifespans based upon production levels and maintenance. The average life of a mold is five years.

The demand for plastic bottles continues to grow in the U.S. across a number of products and sectors including beverage, food, household and automotive chemicals and fluids.

Market changes are shaping the development of plastic bottles and their end-of-life recycling. According to Jahrling, approximately 25 percent of the preform bottling systems (50 per year) are sold into the North American market. "The North American market tends to buy larger machines with average cavitation of 96 or higher, while European machines generally average 72 cavitation," Jahrling stated.

Another indication of the industry's bottling strength and growth is shown in PLASTICS' Committee on Equipment Statistics (CES) survey of North American shipments of plastics machinery such as injection molding and blow molding equipment. For the past six years, plastics machinery shipments have increased year-over-year. The total value of primary equipment shipments for all of 2015 was $1.29 billion, a gain of 4.8 percent when compared with the total from 2014.

However, this pace of investment will likely scale back in the coming years. "Market conditions should remain strong in 2016, but the pace of growth in the shipments data is expected to decelerate after six years of strong expansion," said Bill Wood. "Since the Great Recession in 2009, the average annual growth rate for CES shipments data has been a robust 22 percent per year."

For 2015 as a whole, shipments of injection molding machinery were up 6.4 percent when compared with the total from 2014, while shipments of blow molding machinery dropped 27.5 percent compared to 2014. Steven D. London, president and chief operating officer of Bekum America Corporation, thinks the overall blow molding market will remain at traditional levels, and companies will continue to advance the utilization of multi-layer technology which "promotes the use of post-consumer resins as well as weight reducing agents such as talc fillers and calcium carbonate."

According to PLASTICS data compiled in 2015, there were 455 plastic bottling establishments in the U.S., employing over 30,000 workers around the country. The total value of industrial shipments for the facilities was $1.2 billion with capital expenditures of almost $62 million.

The leading bottling states, according to PLASTICS, are:

California—50 facilities
Illinois—31 facilities
Pennsylvania—31 facilities
Ohio—28 facilities
Texas—25 facilities
Georgia—25 facilities
Florida—23 facilities
Missouri—21 facilities

The largest bottle-to-bottle PET recycling plant is in California while the largest HDPE recycler is in Alabama.

Recycling Progress

Recycling Progress

As plastic bottles have increased their market share in packaging, so too has the recycling rate of plastic bottles. According to APR and the American Chemistry Council (ACC), plastic bottle recycling rates have grown year-after year over the past 25 years. As reported in their National Post-Consumer Plastics Bottle Recycling Report, in 2014, 97 million pounds of plastic bottles were recycled—3.3 percent more than 2013. The overall recycling rate for plastic bottles in 2014 jumped 2014 percent to 31.8 percent.

Recycling is vital not only for the economic value that the material represents, but also the positive impact it has on the environment, including low energy usage and diverting plastics litter and pollution in oceans, rivers and urban areas. It is in the best economic interest of the plastics value chain to support and expand recycling.

In the U.S., single-stream collection of household plastic recyclables is growing and increasing the participation rate; unfortunately, access to away-from-home recycling infrastructure continues to lag and need enhancements. Organizations like Keep America Beautiful and individual companies like PepsiCo are working to enhance recycling offerings in public spaces.

The current Centralized Study on Availability of Recycling for Beverage Containers prepared by RSS and Moore Recycling Associates, Inc.—with the support of PLASTICS and others in the recycling space—found that 92 percent of the U.S. population has programs available for PET bottles/jugs & jar recycling and aluminum beverage can recycling. A smaller percentage of the U.S. population has availability to glass beverage recycling (81 percent) and cartons (55 percent).

Table 3

Availability of Recycling Programs by Material

Availability of Recycling Programs for Each Material	Estimated Population, in Thousands, with Programs Available	Estimated Population, in Thousands, with No Programs Available	Percent of Total US Population with Programs Available
Pet Bottles/Jugs & Jars	284,597	24,149	92%
Aluminum Beverage Cans	282,780	25,965	92%
Glass Beverage Bottles	250,893	57,853	81%
Cartons	168,625	140,120	55%

> "It is in the best economic interest of the plastics value chain to support and expand recycling."

ACC and APR have been measuring U.S. plastic bottle recycling rates to quantify the recycling of plastic bottles. PET and HDPE represent 97.2 percent of the bottles recycled while PP bottles constitute 2.6 percent of plastic bottles recycled.

In 2014, collection of HDPE #2 bottles increased by nearly 1.1 billion pounds; the recycling rate for HDPE bottles rose to 33.6 percent. The total volume of postconsumer PET bottles collected for recycling in the U.S. in 2014 was 1,812 million pounds, an increase of 14 million pounds over 2013. The total weight of PET bottles and jars available in the United States for recycling in 2014 was 5,849 million pounds, a 1.5 percent increase over 2013.

The five year compounded annual growth rate for plastic bottle recycling, according to the ACC/APR study, was 4.1 percent.

Table 4

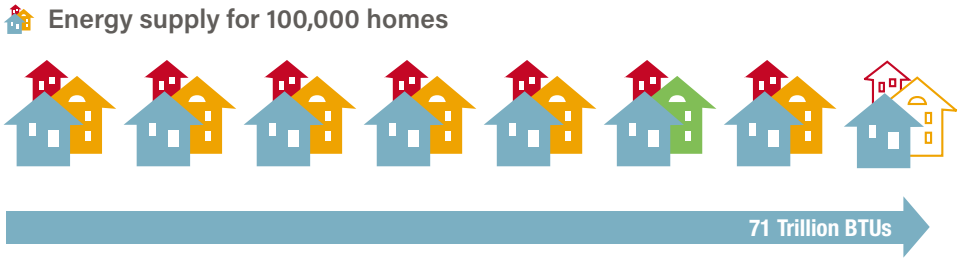
Postconsumer Plastics Bottles Recycled in Calendar Year 2014 Compared to Calendar Year 2013 Results [1,2,3,4,5,6,7]

(in million of pounds per year)

	Calendar Year 2013			Calendar Year 2014		
Plastic Bottle Type	Plastic Recycled [2]	Resin Sales [3,4]	Recycling Rate	Plastic Recycled [2]	Resin Sales [3,4]	Recycling Rate
PET [4]	1798	5764	31.2%	1812	5849	31.0%
HDPE Natural	440.4	1571	28.0%	464.4	1551	29.9%
HDPE Pigmented	605.0	1733	34.9%	643.0	1747	36.8%
Total HDPE Bottles	**1045.4**	**3304**	**31.6%**	**1107.4**	**3298**	**33.6%**
PVC [5]	0.4	76	0.5%	0.3	36	0.7%
LDPE [5]	0.3	78	0.4%	3.6	76	4.7%
PP [6]	62.0	195	31.8%	79.5	177	44.9%
Other [7]	3.8			1.6		
Total Bottles	**2906**	**9417**	**30.9%**	**3003**	**9436**	**31.8%**

Recycled plastics—particularly PET and HDPE—offer significant energy savings and reductions in greenhouse gas emissions, according to a study conducted by Franklin Associates Ltd. Using life cycle inventory (LCI) study results and data from the U.S. Environmental Protection Agency (EPA), the generation of cleaned recycled resin required 71 trillion BTU less than the amount of energy that would be required to produce the equivalent tonnage of virgin PET and HDPE resin; a correlation is the energy saved recycling PET and HDPE containers in 2008 would provide enough energy to supply 750,000 U.S. homes.

Energy Saved Recycling PET and HDPE Containers in 2008



The findings were based upon life cycle assessments (LCA), a methodology to quantify the energy requirements, solid wastes, and atmospheric and waterborne emissions for the processes required to collect postconsumer PET and HDPE packaging, sort and separate the material, and reprocess it into clean, recycled resin.

Most plastic water bottles are recycled through curbside recycling programs, although a handful of states have deposit programs. Monica Filyaw, director of Quality, Safety and Regulatory Affairs for PolyQuest, Inc., said her company's recycling efforts are focused on the deposit programs in order to ensure high quality bales of recycled material.

In 2014, plastic bottle recycling in the U.S. generated an estimated $730 million, providing revenues to local government and local recycling jobs. However, in 2014, there was also a drop in the export of recycled post-consumer plastics, in part due to the strength of the U.S. dollar and China's "Green Fence" initiative to slow the import of postconsumer plastic bales.

Blow molders are focused on the environment and developing ways to improve plastic bottling's sustainability and recycling efforts, according to John Standish, technical director of APR. Standish identifies four strategies being embraced by blow molders on environmental issues including lightweighting, the use of bioplastics, increased usage of recycled content and design for recycling.

"The energy required to make recycled resin is about half that required to make virgin resin. And directly tied to that, the greenhouse gas generation from making recycled resin is about half of that associated with making virgin resin. So including recycled content is an important sustainability effort," Standish explained at a recent blow molding conference.

In addition to recycling, blow molding equipment suppliers are also trying to entice customers to upgrade to newer, energy efficient machines. According to *Plastics News*, blow molders with

> "The energy required to make recycled resin is about half that required to make virgin resin."

the current technology can shorten cycle times, lower energy costs, and allow for quick-change systems to reduce downtime.

Bekum is one of the equipment companies working to reduce energy consumption in the manufacturing process and introduce more non-virgin materials into bottling applications.

"Bekum has released new generation extrusion head technology which enables the customer to not only reduce container weight, it allows them to take advantage of various fillers and non-virgin materials, thereby, reducing virgin material consumption," London said. "In addition, Bekum has developed more efficient extrusion system designs which assist in reducing overall energy consumption and delivering higher throughputs."

Since 2007, Bekum has offered all electric versions of its popular fully automated extrusion blow molding machines that have reduced overall energy consumption by up to 25 percent.

Injection molding equipment has also significantly enhanced its energy usage, adopting fully electric presses, hybrids, and variable displacement pumps and servomotors, to name a few.

Brand owners and bottlers are working to improve sustainability by designing bottles with an eye toward increasing recyclability. "Because if a product goes to landfill, that doesn't help sustainability. If a product goes to waste-to-energy, that might be better than landfill, but it's not as good as designing it so that it's suitable for a next use," Standish said.

According to the ACC/APR study, one of the largest barriers to plastic bottle recycling is that consumers continue to be unaware of the value plastic bottles represent after their usage. "Data and experience show that plastic bottle recycling can be increased through sustained local education campaigns. Municipalities also need to understand that they also can benefit from the sale of bales of bottles, including revenue sharing to fund educational programs and other costs of collection."

Supporting Recycling Programs

Recognizing the need to continue to support and promote recycling, PLASTICS collaborates with The Recycling Partnership (formerly known as the Curbside Value Partnership) to increase residential recycling. The most effective recycling stream is residential recycling, but inconsistent policies and infrastructure have led to inefficiencies and room for improvement.

For instance, according to The Recycling Partnership, only an estimated 21 percent of the U.S. population lives in communities providing a uniform collection program to residents of all building types—single-family homes, small multi-family buildings and large multi-family complexes.

The Recycling Partnership is collaborating with the U.S. EPA on analyzing 400 different curbside programs to gather 17 distinct markers for each program to identify trends and areas for improvement. The EPA believes the data will help communities enhance their materials management and recovery.

Cody Marshall, The Recycling Partnership's technical assistance lead said, "Looking at snapshots of programs across the country will allow us to cross-reference best practices and pinpoint opportunities to increase recovery. Those insights will in turn allow national and federal organizations to create targeted action plans."

The research effort will catalog information on 39 categories of recyclable materials, along with collection frequencies, tonnages, funding mechanisms, service providers and a host of other details. It will analyze this data for trends and gaps in curbside recycling infrastructure, and ultimately deliver a graphically rich summary report along with the full database.

PLASTICS National Survey Reflects Consumer Attitudes on Recycling

The current state of the nation's recycling infrastructure—and attitudes toward recycling—was also reflected in PLASTICS's national poll in 2016 of 1,107 adults nationwide (with a margin of error of +/- 3.07 percent at the 95 percent confidence interval). In the survey, 72 percent of participants had curbside recycling while 28 had central or community sites; 71 percent of the curbside recyclers had access to single-stream recycling that did not require any sorting.

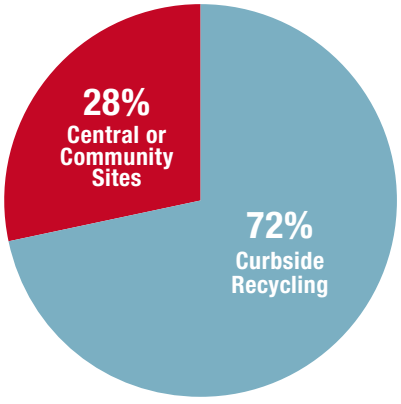
The survey indicated 77 percent of participants recycled plastic products and packaging "all of the time" or "most of the time" and only 13 percent "rarely" or "never" recycled plastics. Half of those not recycling regularly said the biggest hurdle was primarily due to the lack of pick up or curbside recycling. Only eight percent of respondents were pessimistic in reporting recycling "doesn't make a difference."

The responsibility for recycling plastics, according to the survey respondents, leaned towards consumers (56 percent) over companies that make plastics (31 percent). A slight majority also thought the plastics industry was "definitely" or "probably" doing a good job promoting recycling. The plastics industry has adopted a more collaborative view of involving multiple stakeholders—from brand owners and governments to consumers and business.

In sum, the poll reflects that Americans' self-reporting of recycling plastics is high, and consumers value the importance of recycling. However, infrastructure improvements could be made to increase overall recycling rates around the nation. Promotion of recycling seems to be welcomed and consumers have a sense of personal responsibility to recycle plastics.

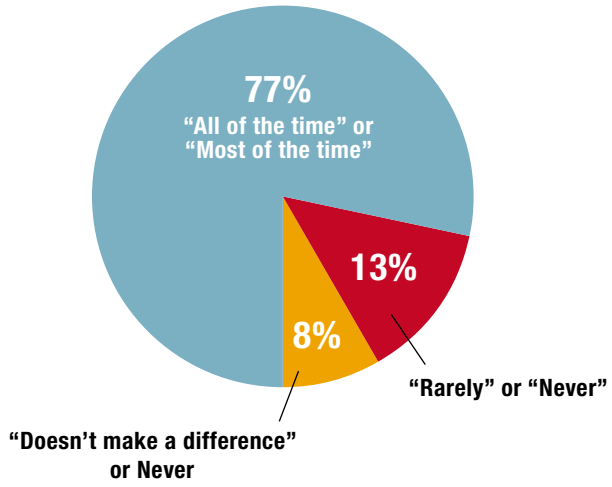
Access to Recycling

Poll of 1,107 adults nationwide



Attitudes about Recycling

Poll of 1,107 adults nationwide



Coca-Cola

The Coca-Cola Company introduced its first two-liter PET plastic bottle in 1978. The bottle was immediately accepted by consumers because it was unbreakable and resealable. Over the years, the plastic bottling technology has advanced, making the PET bottles more lightweight and recyclable. In 1991, Coca-Cola introduced its PET bottle with recycled content, underscoring the company's commitment to recycling and reuse of its bottles.

"We are trying to check a lot of boxes with any of our projects; we try to get to multiple end points at the same time," said Berrier. "We are reducing costs; we are de-materializing containers by making them thinner, lighter, and using less plastic. We are also trying to extend shelf life of our products. We see some plastics that do a better job holding out oxygen or holding in carbon dioxide; these play out with respect to shelf life."

> "We are reducing costs; we are de-materializing containers by making them thinner, lighter, and using less plastic."

On the recycling side, Coca-Cola has been operating bottle-to-bottle recycling plants since 1999, and currently has facilities in Australia, Austria, Mexico, the Philippines and the United States. The transportation costs associated with getting the plastic bottles back to the recycling facility are high, but due to plastics lightweight properties, the costs (and weights) are less than glass recycling.

According to Berrier, innovation on the front end of plastics and the development of new polymers is outpacing the back end, end-of-life management and recycling of plastics. "We need to think about ways to improve the collection network and methods—getting the plastic back from consumers and getting it cleaned up for recycling." Berrier said Coca-Cola is looking to a "Golden Triangle" of industry, government and academia to find solutions to recycling problems.

PlantBottle®, the first recyclable PET plastic bottle made partially from plants, was introduced in 2009 by Coca-Cola. The biobased bottle reduced the company's use of petroleum and lowered its potential carbon dioxide emissions.

> "We need to think about ways to improve the collection network and methods—getting the plastic back from consumers and getting it cleaned up for recycling."

Conclusion

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The next 10 years will hold a decidedly positive outlook for the U.S. and global plastic bottling market, based on statistics and insights across the entire plastics supply chain. U.S. demand for beverage containers is expected to increase 1.9 percent a year to 283 billion units in 2019. Plastic containers will remain the largest and fastest growing for beverages with gains supported by the growing bottled water market. However, the Freedonia Group notes that plastics will also gain ground in newer uses, including ready-to-drink (RTD) tea, RTD coffee and larger sizes of alcohol beverages. With the demands for plastic beverage containers proliferating, plastic bottle manufacturers are challenged to meet the diverse needs.

> "A macro trend impacting the plastic bottle manufacturing market is sustainability."

Advancements in manufacturing, resins and packaging are pacing the industry's growth. Low feedstock costs are encouraging the utilization and adoption of plastics. New technologies in blow molding and other manufacturing processes are reducing energy costs, improving performance and offering added lightweighting benefits.

Focusing on their customers, brand owners are pushing design innovations in plastic bottling that are unparalleled in the rest of the packaging sector, such as weight savings in transport and manufacturing. Recycled and bio-based plastics are used across brands, with some companies developing next-generation bottles. The pace at which brand owners can adapt their plastic packaging surpasses other packaging materials like glass and paper. The plastic bottle is a modern era envelope that brands can easily embrace for their products.

To continue to facilitate future growth and innovation, beverage packaging manufacturers need to assist bottle manufacturers in optimizing their assembly lines, reducing their carbon footprint, supplying faster machines, offering lightweight, recyclable containers and helping with packaging design.

Two opposite trends are impacting the plastic bottle manufacturing market right now: dedicated versus flexible lines. Today, we see some dedicated lines, which basically do one product or one product line only, and then we see some flexible lines.

Both mean something totally different for the manufacturing equipment. On the dedicated lines, fast output is the main focus; in other words, bigger, faster machinery, and obviously optimized design to have the smallest cost possible to manufacture the bottles.

With more flexible lines, big lines make no sense. These operations require smaller machines combined with blow molder filler blocks that support fast changeover. The beverage-makers' need for fast changeover is driven by the SKU proliferation impacting the market. In conjunction with extremely fast changeover, they want low energy consumption as well.

A macro trend impacting the plastic bottle manufacturing market is sustainability. Whether its energy output from the machinery or material lightweighting, equipment manufacturers must help brand owners employ more sustainable practices.

Alternatively, the responsible use of virgin PET across the supply chain can bring immediate and significant sustainability benefits. "In its recycled form, PET can be reused time and time again, reducing consumption of what is a finite resource," Nicholas Bloch, Executive Vice President of Group Communications at Sidel, continues. "Already the most widely recycled plastic in the world, through initiatives to further improve collection rates and the methods of recycling, PET can further strengthen its position as the sustainable package of choice. It is about taking what is currently in the waste stream and putting it in the resource stream, reaching for the ultimate objective of a closed-loop, sustainable packaging supply chain."

To reduce the overall carbon emissions produced throughout the life of a finished bottle, bottlers increasingly are using recycled PET (rPET) or bio-based PET resin. Many are also reducing or eliminating altogether the secondary packaging that accompanies the product, such as shrink-wrapping and over-wrapping. An additional area of cost-savings is found in replacing bottle rinsing with dry decontamination of PET preforms to save on water.

Lightweighting also advances sustainability. However, lightweighting a bottle should not compromise bottle performance or the consumer experience. So for example, designs are needed which prevent the 'over squeeze' issue that can result in the spilling of contents unintentionally when using ultra-light bottles. In addition, as plastic bottle weights have come down, the pressure on the machinery that manufactures these bottles has increased.

"The lighter the bottles get, the narrower the process window becomes," Arne Wiese, product manager of bottles and shapes for KHS Corpoplast GmbH explains. "In other words, we have to make the machines more precise and find

possibilities to get the blow molding process more precise."

Among the ways the company has addressed this is by utilizing a profiler that bundles energy on a line on two to three millimeters, he notes. "For extreme lightweight preforms, where we always have the problem to decide where the body starts to develop mechanically, now we thermally have the possibility to always have the bottle body weight," Wiese says. "It always is the same weight as in the thread and the spot ledge diameter and the same amount of material."

In the competitive beverage industry, innovation is key. In the last few years, companies have developed new categories, such as coconut waters, aloe-infused drinks and relaxation beverages. Because formulations like these are so creative, oftentimes their packaging must be, too. Advancements in new compact, easy-to-use, remotely operated equipment will drive future innovations. More sophisticated data usage will enable a more proactive management of the line. Key advances are being made in this area, and new systems will offer embedded machine intelligence to increase self-monitoring and process automation.

When it comes to bottle shapes, a variety of options are available for beverage-makers. This flexibility is driving the future of plastic bottle manufacturing. And in the passenger seat is environmental impact. Blow molding machines must allow marketing freedom to bottlers in order to enable a wider differentiation in terms of packaging design and product segmentation. Along with this freedom, greater flexibility and compatibility with new types of resins, such as those containing a percentage of recycled materials, is also required.

The front-end, beginning-of-life development of plastics, rooted in the private sector and innovation, is outpacing the end-of-life management and recycling of all plastics. The supply chain that pushes the development of new plastics and plastic bottling is outpacing the recycling technologies and resources that fund and manage recycling of plastics. Incremental improvements in recycling—from expanded availability of curbside recycling at households to zero-waste events and venues—need to be embraced and expanded.

Perspectives of an empty plastic soda bottle or laundry detergent container are changing—more and more people in the U.S. and around the world see value in plastics; but current economic realities of virgin plastic costs and recycling costs (collecting, cleaning, processing, transporting) are factors that cannot be ignored by brand owners. Still, all participants in the plastics value chain—including recycling players and all levels of government—need to continue supporting recycling capabilities, facilities and technologies. The examples of European nations in reducing landfilling should be seen as a laboratory for the U.S. recycling system.

These dynamics will be featured and explored at the NPE2018 Bottle Zone. PLASTICS and the plastics industry must be leading advocates for plastics innovation from end-to-end. The Bottle Zone will be a central point for industry professionals to gather and share new developments and ideas to bolster the growth and management of plastics.

"The Bottle Zone at NPE2018 provides an opportunity for companies representing the entire supply chain to exhibit their equipment and share trends, innovations and best-practices to address the needs of today's increasingly perceptive and conscious consumer," said Mark Garrison, senior vice president of membership and business development at PLASTICS.

The future of plastics bottling is in the hands of the value chain, the maturity of the industry is set and plastics has shown its ability to adapt and shift through market forces; the Bottle Zone will be crucial for the industry's continued expansion and sustainability.

Plastic Bottle Glossary

Plastic Bottle Glossary

Plastic bottling encompasses a wide range of technology and participants in the value chain. MTM Systems offers the following glossary of key terms:

Aesthetics: The sum total of the visual response to the beauty of an object. Elements of aesthetics may include: color, shape or particular features of the object.

Aging: The physical and/ or chemical changes of a material with respect to time, under defined environmental conditions, leading to improvement or deterioration of properties.

Amber: A chromatic (brown) color of glass or plastic containers. It is used principally to protect the contents of the container from exposure to light.

Antioxidants: A chemical substance added to a plastic resin to minimize or prevent the effects of oxygen attack on the plastic, e.g., yellowing or degradation. Chemical attacks by oxygen can render a plastic brittle or cause it to lose desired mechanical properties.

Antistatic Agent: A chemical substance applied to the surface of a plastic article or incorporated in the plastic from which the article is made. The antistatic agent renders the surface of the plastic article less susceptible to the accumulation of electrostatic charges, which attract and hold fine dirt or dust on the surface of the plastic article.

Barrier Resins: A group of resins specially formulated to resist the transmission of oxygen, water, solvents, essential oils, etc.

Blow Mold: Cavity that receives the Preform, which will be blown into the desired shape.

Blow Pin: Used in Extrusion Blow Molding. Hollow tube that pierces Preform and introduces air to blow Preform into shape of Blow Mold.

Buttress Thread: A design of thread profile (cross section), which takes the form of a truncated triangle. It is usually positioned so the right angle is at the bottle of the thread cross section and adjacent to the neck of the bottle finish. The horizontal leg of the right triangle is the bearing surface for a matching cap thread. It is designed to withstand maximum force in one direction only.

Capacity: (1) The amount of space provide inside a container for a given amount of product. (2) The total amount of volume inside the container. The latter is more correctly called the overflow capacity.

Cavity: That part of the mold, which contains the reverse image of the product being formed.

Clarity: Freedom of haze or cloudiness in a plastic material. PET bottles offer great clarity.

Closure: A devise used to seal off the opening of the bottle to prevent the loss of its contents. SKS offers a wide selection of closure options.

Cobalt: A blue colored plastic.

Color Concentrate: A measured amount of dye or pigment incorporated into a predetermined about of plastic. This pigmented or colored plastic is then mixed into larger quantities or plastic material used for molding. The concentrate is added to the bulk of plastic in measured quantity in order to produce a precise, predetermined color of the molded bottles

Cold Runner: Flow channel for heat-softened polymer, which goes from the Plastifier to the mold cavities. Polymer in the flow channel is cooled with shaped parts in cavities and is later removed, reground, and reused.

Continuous Thread: An uninterrupted protruding helix on the neck of a container used to hold screw-type closures.

Copolymer: A material whose chemical structure is made of long chins of two differently structured chemical units (Monomers) which repeat a more or less regular pattern in the chain.

Core: The part of a mold that allows the internal shaping of a product such as the internal threads of a cap.

Core Rod: Used in Injection Blow and Injection Stretch Blow Molding. Used in conjunction with a Preform Mold to manufacture a Preform. The Preform is formed around the Core Rod creating a hollow tube, which will then be transferred to a Blow Mold where air will be introduced forcing the Preform to take the shape of the Blow Mold cavity.

Deflashing: Any technique or method removing excess unwanted material from a molded article. Specifically, the excess material is removed from places on the article where parting lines of the mold that formed the article may have caused the excess material to be formed.

Density: Weight per unit volume of a substance. Density is expressed in grams per cubic centimeter, pounds per cubic foot, etc.

Drop Test: Any test method in which the article being tested is dropped in a specified manner for a specified number of times, or until the article fails from impact.

Discoloration: Any change from the original color. Discoloration is often caused by overheating, light exposure, irritation, or chemical attack.

"E" Dimension: The outside diameter of neck on a threaded bottle neck (finish) is measured across the root of the threads.

Environmental Stress Cracking (ESC): The susceptibility of a thermoplastic article to cracking under the influence of certain chemicals and stress.

Extrusion Blow Molding: A molding process whereby heat-softened polymer is forced into the shape of a hollow tube. While still soft, a mold closes around the tube, pinching the top and bottom of the tube closed. A Blow Pin is introduced, and air is forced through the pin forcing the tube to take the shape of the Blow Mold cavity.

Fill Point: The level to which a container must be filled to furnish a designated quantity of the contents.

Finish: The plastic forming the opening of a container and shaped to accommodate a specific closure.

Fitment: A device used as part of a closure assembly to accomplish a certain purpose such as, dropper, sprinkler, powder shakers, etc.

Flame Treating: A method of rendering inert thermoplastic objects receptive to inks, lacquers, paints, adhesives, etc., in which the object is bathed in an open flame to promote oxidation of the surface of the article.

Flash: Extra plastic attached to molded ware along the parting line, which must be removed before the part can be considered finished.

Fluorination: An extra process in which a thermoplastic article (container or closures) is exposed to fluorine gas. The fluorine substitutes some hydrogen atoms in the polymer chain creating a barrier and surface enhancement. Benefits include improved barrier properties and reduced solvent absorption and permeation.

Gate: Used in Injection. Injection Blow, and Injection Stretch Blow Molding. The orifice through which the heat-softened polymer enters the cavity.

"H" Dimension: The height of the bottle finish measured from the sealing surface, in a line parallel to the axis of the finish and tangent to the threads on the finish, down to a point where the line intersects the body (shoulder) of the container. The inside height of the closure measured from the bottom of the closure, in a line tangent to the threads of the closure and terminating at the inside, top of closure.

HDPE: An abbreviation for High Density Polyethylene

Head Space: The space between the fill level of a container and the sealing surface.

Heel: The part of a bottle between the bottle bearing surface and the side wall.

Hot Runner: Flow channel for heat-softened polymer, which goes from the Plastifier to the mold cavities. Polymer in the flow channel is kept softened so there is no runner material to grind up and reuse.

Hopper: Conical feed reservoir into which polymer pellets are loaded. These pellets then fall into a heated barrel (Plastifier), sometimes through a metering device.

Hygroscopic: Tending to absorb moisture.

"I" Dimension: A specified minimum diameter inside the bottleneck. A minimum diameter is specified to allow sufficient clearance for filling tubes to enter the bottle neck easily.

"I.D.": An abbreviation for inside diameter.

Impact Resistance: Relative susceptibility of plastic to fracture by shock. Impact resistance is indicated by the energy expended by a standard pendulum type impact machine in breaking a standard specimen in one blow.

Injection Blow Molding: A molding process in which heat-softened polymer is injected from a Plastifier into a mold cavity creating a Preform, which is then transferred to a Blow Mold where air is blown into the Preform, forcing it to take the shape of the Blow Mold cavity.

Injection Molding: A molding process whereby a heat-softened polymer is injected from a Plastifier into a relatively cool cavity, which gives the article the desired shape.

Injection Molds: A mold into which a plasticated material is introduced from an exterior heating cylinder.

Injection Stretch Blow Molding: A molding process whereby Preforms are introduced into a cavity, stretched axially by a Stretch Rod, and then blown circumferentially to the shape of the Blow Mold cavity.

"L" Dimension: The vertical distance from the sealing surface to the top part of neck bead, i.e. where the uppermost part of the bead intersects the container neck.

"L" Style Thread: A type of thread contour (cross section) roughly trapezoidal in outline. The outermost part is a "general purpose" thread contour designed for use with metal or plastic closures.

Light Resistance: The ability of a plastic material to withstand exposure to light, usually sunlight or the ultraviolet part of the light spectrum, without change of color or loss of physical and/or chemical properties.

Lug: (1) A type of thread configuration designed so the thread segments are disposed equidistantly around a bottle neck (finish). The closure has matching proportions that engage each of the thread segments. (2) A small indentation or raised portion on the surface of a container. The lug provides a means of indexing the container for operation such as multi-color decoration or labeling.

Melt Index: The amount, in grams, of a thermoplastic resin, which can be forced through a 0.0825-inch orifice when subjected to 2160 gms. force in 10 minutes at 190° C.

Mil: A unit of measurement equal to .001 inch.

Minimum Wall: A term designating the minimum thickness of the wall of a bottle.

Moisture Vapor Transmission Rate (MVTR): The rate at which water vapor permeates through a plastic film or bottle wall at a specified temperature and at relative humidity.

Mold: Contains the cavity or cavities of a desired part in which a heat-softened polymer is shaped.

Mold Seam: A line formed at the point of contact of the Mold halves.

Multi-layer Bottle: A bottle that is co-extruded with two or more layers to container oxygen sensitive foods or industrial chemicals.

Narrow Mouth: A finish of a plastic container in which the diameter is small relative to the diameter of the body.

Neck: The part of a container where the shoulder cross section area decreases to form the finish.

Neck Ring: Part of the mold assembly, which forms the neck and finish of a container.

Nozzle: Hollow cored orifice that is screwed into the extrusion end of the Plastifier. The nozzle is designed to form a seal under pressure between the Plastifier and the Mold or Runner System. The front end of a nozzle may be either flat or spherical in shape.

Offset Printing: A printing technique in which ink is transferred from a reservoir to printing plate. For the ink printing plate, the image is printed on a cylindrical rubber roll (blanket) and then to the object to be printed.

Opaque: A term describing a material of substance, which will not transmit light.

Orientation: The alignment of the crystalline structure in polymeric materials so as to produce a highly uniform structure. Orientation can be accomplished by cold drawing or stretching during fabrication.

Overflow Capacity: The capacity of a container to the top of the finish or to the point of overflow.

Paneling: Distortion, sidewall collapse of a container occurring during aging or storage. Paneling is cause by the development of a reduced pressure inside the bottle.

Parting Line: A mark on a molding or casting where the halves of mold meet in closing.

Permeability: (1) The passage or diffusion of a gas, vapor, liquid or solid through a barrier without physically or chemically affecting it. (2) The rate of such passage.

PET: (Polyethylene Terephthalate) known as thermoplastic polyester. PET has the unusual ability to exist in either an amorphous or highly crystalline state. The crystalline state is necessary for extruding the material. The amorphous state permits it to be oriented.

Plasticize: To soften a material and make it plastic or moldable by means of a plasticizer or the application of heat.

Plastifier: Assembly whereby polymer pellets are fed from a Hopper into a barrel where they drop onto a turning screw which forces the pellets forward. Heater bands wrapped around the barrel melt the pellets as they are forced forward along the inside of the barrel. The molten polymer is then forced out the end of the barrel through the Nozzle.

Polyolefins: (HDPE, LDPE, PP, etc.) are primarily those polymers that are flame treated.

Polyethylene: A thermoplastic material composed of polymer of ethylene. It is normally a translucent, tough, waxy solid unaffected by water and a large range of chemicals.

Polypropylene: A tough, light-weight rigid plastic made by the polymerization of high-purity propylene gas in the presence of an organometallic catalyst at relatively low pressure and temperatures.

Polystyrene: A water-white thermoplastic produced by the polymerization of styrene (vinyl benzene).

Polyvinyl Chloride (PVC): A thermoplastic material composed of polymer of vinyl chloride. PVC is a colorless solid with outstanding resistance to water, alcohols, and concentrated acids and alkalies.

Pour-Out Finish: A container finish having uniform undercut lips as a sealing surface. The pour-out finish is designed to facilitate pouring with out dripping.

Preform: Used in Blow Molding processes. Heat-softened polymer is formed into a shape similar to a thick test tube with neck threads. This tube is subsequently inflated while inside a Blow Mold to create the shape of the desired article.

Programming: The extrusion of parison, which differs in thickness in the length direction in order to equalize wall thickness of the blown container. It can be done with a pneumatic or hydraulic device, which activates the mandrel shaft and adjusts the mandrel position during parison extrusion (parison programmer controller, or variator.) Varying extrusion speed on accumilator type blow molding machines can also do it.

Push Up: The recessed area on the bottle of a bottle designed to allow an even bearing surface on the outside edge to prevent the bottle from rocking.

Regrind: A thermoplastic from a processor's own production that has been reground or re-pelletized after having been previously processed by molding.

Release Agent: A lubricant that facilitates molding.

Resin: Any class of solid or semi-solid organic products of natural or synthetic origin, generally of high molecular weight, with no definite melting point. Most resins are polymers.

"S" Dimension: Locates the position of the bottle thread with respect to the sealing surface. The "S" dimension is the vertical distance from the sealing surface to the intersection of the finish wall and the top part of the first part of bottle thread where full depth contour exists.

Screen Printing (ACL): A printing technique involving the passage of printing medium, such as ink through a web or fabric, which has been stretched on a frame, to which a refined form of stencil has been applied. The stencil openings determine the form and dimensions of the imprint thus produced.

Sealing Surface: The lip portion of the finish that make contact with the sealing gasket or liner to form a seal.

Shrinkage: The change in dimension (decrease) a molded article undergoes after being molded. Shrinkage is caused by cooling and subsequent contraction of the plastic material.

Stretch Rod: Used in Injection Stretch Blow Molding. A rod that is introduced into the Preform to stretch it in an axial direction prior to the Preform being blown into the shape of the cavity.

Surface Treating: Any method of treating a plastic to alter the surface and render it receptive to inks, paints, lacquers and adhesives. Examples of surface treating are chemical, flames or electronic treating.

"T" Dimensions: The outside diameter of the thread helix on a bottle finish.

Thermoplastic: Material that will repeatedly soften when heated and harden when cooled. Capable of being repeatedly softened by heat and hardened when cooled. Typical of the thermoplastics family are the styrene polymers and copolymer, acrylics, celluloses, polyethylene, vinyl's, nylons, and the various fluorocarbon materials.

Top Load: The amount of weight bearing on the top of a container. The term is sometimes used to indicate the maximum load the container will bear without becoming distorted.

UV Stabilizer: Any chemical compound which, when a thermoplastic resin, selectively absorbs UV rays and minimizes chemical and/ or physical changes that may be engendered by UV.

Volume: Referred to as "displacement" and also as "capacity." (1) The amount of water displace by a model of a bottle. Volume is used to estimate its capacity. (2) The about of product a bottle is designed to hold, i.e. up to the fill point of the bottle. (3) The over flow capacity, i.e. the amount of product a bottle will hold when filled to overflowing.

Plastic Bottle Dimensions

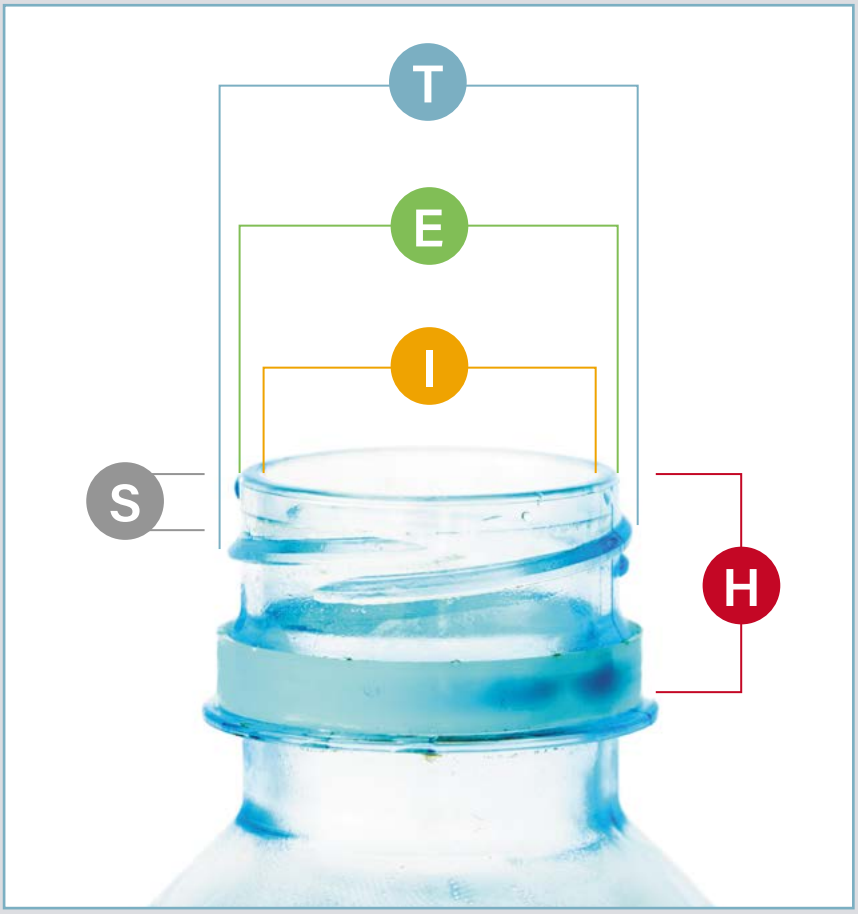
E **Dimension:** The outside diameter of neck on a threaded bottle neck (finish) is measured across the root of the threads.

H **Dimension:** The height of the bottle finish measured from the sealing surface, in a line parallel to the axis of the finish and tangent to the threads on the finish, down to a point where the line intersects the body (shoulder) of the container. The inside height of the closure measured from the bottom of the closure, in a line tangent to the threads of the closure and terminating at the inside, top of closure.

I **Dimension:** A specified minimum diameter inside the bottleneck. A minimum diameter is specified to allow sufficient clearance for filling tubes to enter the bottle neck easily.

S **Dimension:** Locates the position of the bottle thread with respect to the sealing surface. The "S" dimension is the vertical distance from the sealing surface to the intersection of the finish wall and the top part of the first part of bottle thread where full depth contour exists.

T **Dimensions:** The outside diameter of the thread helix on a bottle finish.



Descriptions of Plastic Resins

Polyethylene Terephthalate: This type of plastic is used for its strength, impact resistance, clarity and barrier resistance to things such as moisture, oxygen and many chemicals. PETE is typically produced in clear, but can also be done in colors such as green and amber.

High Density Polyethylene: The natural state of HDPE is a cloudy, slightly translucent color. It has good chemical resistance, does not absorb moisture and provides a good water vapor barrier. HDPE is one of the most popular plastics for molding bottles and containers.

Polyvinyl Chloride: Typically clear in appearance when used for containers. PVC has outstanding resistance to water, alcohols, concentrated acids and alkalines. PVC can be produced to yield superior flexibility.

Low Density Polyethylene: Translucent in color with a tough, waxy texture. LDPE is a very flexible plastic with good barrier properties.

Polypropylene: It is best known for its flexibility and versatility. It can be molded into many applications; the most popular use in packaging is for closures. PP is very tough and has good chemical resistance. Although normally translucent in appearance, PP can be made a variety of colors.

Polystyrene: A very clear, rigid plastic. PS has good chemical resistance, but no moisture or oxygen barrier properties. PS tends to be brittle, so cracks and breaks easily.

Other: Can be any combination of plastics. Usually one of the above plastics mixed with an additive or barrier plastic to enhance the properties of the final container.

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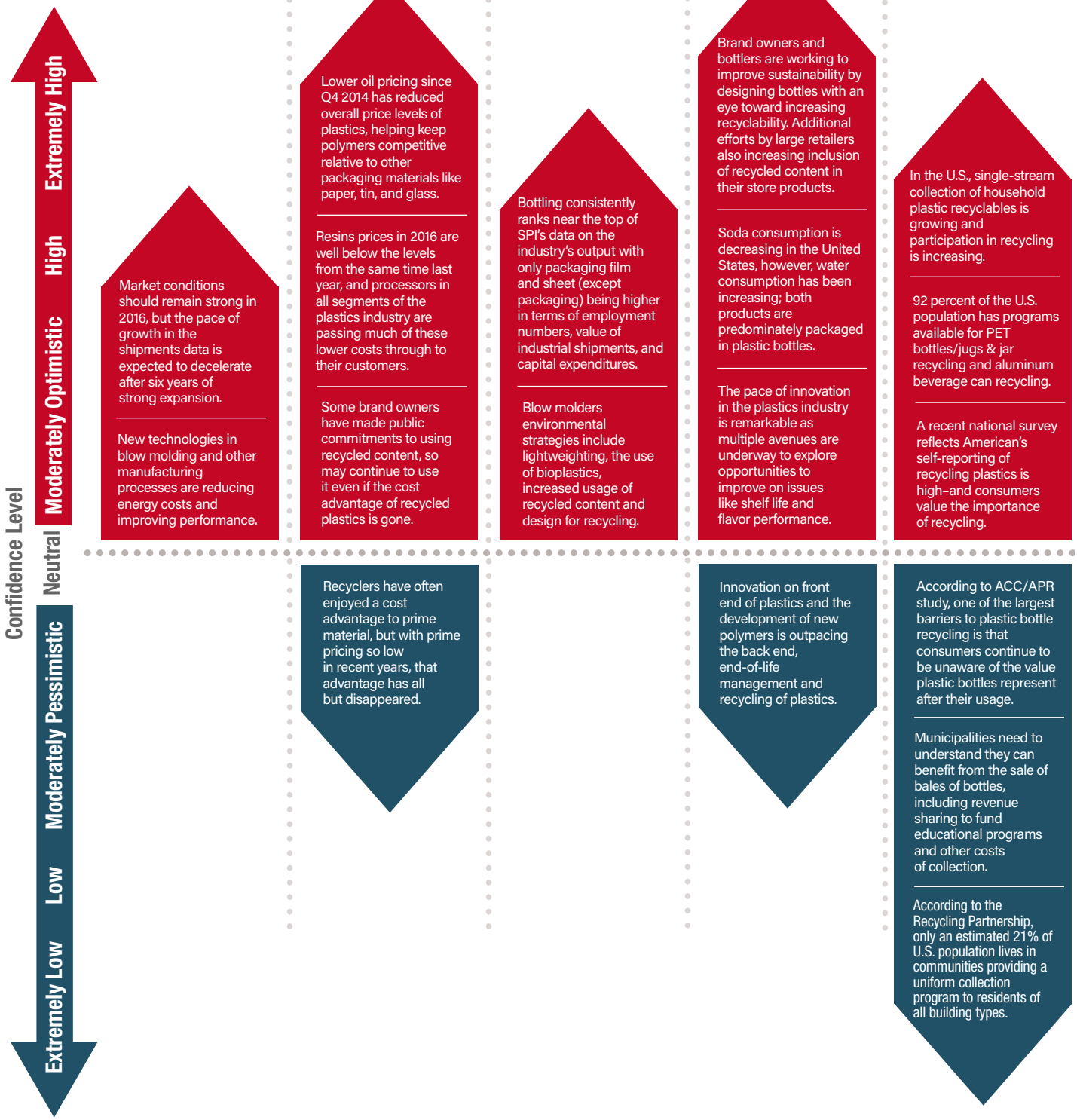

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