U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON RESEARCH & TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HEARING CHARTER

Closing the Loop: Emerging Technologies in Plastics Recycling

Tuesday, April 30, 2019
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

PURPOSE

On Tuesday, April 30, 2019, the Subcommittee on Research and Technology of the U.S. House of Representatives Committee on Science, Space, and Technology will hold a hearing titled, *"Closing the Loop: Emerging Technologies in Plastics Recycling."* The purpose of this hearing is to examine plastics recycling challenges in the United States and discuss new and emerging technologies to reduce the lifecycle environmental impact of plastic.

WITNESSES

- **Mr. Paul Sincock**, City Manager, City of Plymouth, Michigan
- **Dr. Govind Menon**, Director, School of Science and Technology, Chair, Department of Physics and Chemistry, Troy University
- **Dr. Gregg Beckham**, Senior Research Fellow, National Renewable Energy Laboratory
- **Mr. Tim Boven**, Recycling Commercial Director, Packaging & Specialty Plastics, Dow

OVERARCHING QUESTIONS

- What is the status of plastics recycling in the U.S.? What are the current and long-term challenges to meeting the demand for plastics recycling and reducing the environmental impact of plastics?
- What research and development is needed to advance innovations in plastics recycling at different stages along the lifecycle of the plastics material? What new materials, processes and other technologies are being explored? What standards are needed to advance innovation and grow the U.S. industry?
- What is the role of federal science agencies in supporting research and development in plastics recycling? What is the role of the private sector? How can federal agencies best partner with the private sector to advance innovations in plastics recycling to grow the U.S. industry and reduce the environmental impact?

U.S. Plastic Recycling – General History and Overview

The three word mantra "Reduce. Reuse. Recycle." with the accompanying green-arrowed triangle, arose from the environmental movement of the 1970s and is still in use today. The *Resource Conservation and Recovery Act of 1976* included authorization to promote a national research and development program for new and improved methods of collection, separation, recovery, and recycling of solid wastes. This national effort to recover valuable petroleum-based resources that were filling landfills drove the growth of the U.S. plastics recycling industry in the 1980s, for both post-consumer and post-industrial plastics. The most recent data from the Environmental Protection Agency shows that the recycling industry overall was responsible for 757,000 jobs, $36.6 billion in wages, and $6.7 billion in tax revenues in 2007.[1]

The OECD estimates that global production of plastic has increased from two million tons of plastic per year in 1950 to 400 million tons per year today.[2] Of the 5.9 million pounds of polyethylene terephthalate (PET) bottles sold in the U.S. market in 2017, 29.2 percent were collected through recycling programs.[3] While this hearing will focus on technology's role in plastics recycling, there are several factors driving national discussions about plastics recycling. As the U.S. recycling market was growing, the U.S. recycling infrastructure did not keep pace with domestic demand. As a result, China's steadily growing recycling industry became a competitive market for post-consumer plastics from the U.S. For more than two decades, the U.S. and other developed nations sold and exported 106 million metric tons of recyclable plastics to China.[4] In 2018, China implemented a policy to prohibit the purchase of most U.S. plastics collected for recycling because of contamination levels, and some say because China wants to build its own raw materials market. In addition, plastics recycling can be a labor and capital-intensive industry in which the resulting products may be more expensive. Therefore, when oil prices are low, making plastics from virgin resin is more economically efficient than using recycled content.

Many American communities have been recycling for decades. Others never implemented recycling. Now, with China's ban in effect, some communities that once recycled don't have access to an affordable facility that will purchase and process their items collected for recycling. Therefore, more and more communities are sending recyclable items to landfills or incinerators

[1] 2016 Recycling Economic Information Report (REI). https://www.epa.gov/smm/recycling-economic-information-rei-report

[2] OECD, *Improving Markets for Recycled Plastics: Trends, Prospects and Policy Responses,* 2018. http://www.oecd.org/env/waste/improving-markets-for-recycled-plastics-9789264301016-en.htm

[3] National Association for PET Container Resources (NAPCOR) and Association of Plastic Recyclers Report on Postconsumer PET Container Recycling Activity in 2017. https://plasticsrecycling.org/images/pdf/resources/reports/Rate-Reports/Reports-on-Postconsumer-PET-Container-Recycling-Activity/APR_NAPCOR_2017RateReport_FINAL.pdf

[4] Watson, Sara Kiley, "China Has Refused to Recycle The West's Plastics. What Now?," NPR, June 28, 2018. https://www.npr.org/sections/goatsandsoda/2018/06/28/623972937/china-has-refused-to-recycle-the-wests-plastics-what-now

as a less expensive means for disposal. Today, some estimates show that 40 percent of Americans do not have access to recycling,[5] others report that 52 percent of Americans don't feel that they have access to recycling, [6] and yet others find the opposite - that 94 percent of the U.S. population has some type of recycling program available to them.[7] In addition, of the 8.3 billion metric tons of plastic ever produced globally, 6.3 billion metric tons has become plastic waste, and of that, only nine percent has been recycled. Data on plastics recycling by country is limited, but according to the best available data, the U.S. recycles only 9 percent of its plastic, compared to 25 percent in China and 30 percent in Europe.[8]

Current Recycling Processes and Challenges

For those living in communities with recycling programs, how to recycle and what can be recycled are decisions made on a municipality by municipality basis with no national guidelines. Early recycling procedures in many cities required residents to sort glass, newspaper, cardboard, plastics, metals and so on in different curbside bins or at a recycling facility. Later, many cities adopted "single stream" recycling, in which all recyclable items go in one large curbside bin. This was done in an effort to both increase recycling rates and lower collection costs for cities facing tight budgets. Cities typically contract with a hauler to truck these items to mostly privately owned materials recovery facilities (MRFs) that sort all of the collected items manually, with an optical sorter machine, or both. MRFs may further sort plastics by type of plastic, for example water and soda bottles made of polyethylene terephthalate (PET). Once sorted, the MRFs configure these items into bales to be sold and shipped to a recycler, domestic or foreign. Once at the recycler, items may be undergo a second sort by a number of factors including type of plastic or color, then they are washed, shredded into flakes, and melted into pellets that can be extruded to form a new item.

A high-quality sorting process that produces a clean bale of plastic is a meticulous process. Some plastics, such as PET, can be tinted many colors that produce a green or dark colored resin when mixed together. There are some low-value applications, such as carpet backing, that can utilize the resin resulting from a mixed PET bale. This is known as "downcycling." Food quality packing, for example a clear plastic bottle from recycled materials, requires a much more rigorous sorting process and better grade of resin.

[5] Peters, Adele, "All the Ways Recycling is Broken – And How to Fix Them," Fast Company, April 4, 2019. https://recyclingpartnership.org/article-all-the-ways-recycling-is-broken-and-how-to-fix-them/

[6] Maile, Kelly, "Americans Could Know More About Recycling," Recycling Today, December 21, 2018. https://www.recyclingtoday.com/article/recycling-partnership-surveys-residents-about-recycling-2018/

[7] Desilver, Drew, "Perceptions and Realities of Recycling Vary Widely From Place to Place, Pew Research Center, October 7, 2016. https://www.pewresearch.org/fact-tank/2016/10/07/perceptions-and-realities-of-recycling-vary-widely-from-place-to-place/

[8] Geyer, R., Jambeck, J. R., & Law, K.L., "Production, Use, and Fate of All Plastics Ever Made," Science Advances, 2017.

Plastics recycling is a relatively new industry compared to mature recycling processes of other materials, such as metals, which have high rates of recycling. Plastics recycling faces unique challenges that other materials do not. A significant amount of post-consumer plastics are food packaging materials that may not have been cleaned thoroughly before being placed into a recycling bin. If a handler or a machine at a MRF does not remove containers with food residue or an unemptied soda bottle, for example, it may contaminate a whole bale which then goes to a landfill. Additionally, while more items are collected in single-stream curbside recycling bins, fewer items are actually being recycled because people are placing items in their bins that they hope are recyclable but are not, including such items as bowling balls and blenders. Unfortunately, these are often items that the MRF is not able to sort out or items that damage the MRFs equipment. Many of these bales also end up being sent to the landfill, recyclables and all. The recycler that is purchasing the material makes the determination of the level of contamination they will accept in a bale. A rejected bale means lost transportation costs to the MRF, which is one of the biggest expenses in recycling.

Another significant source of contamination is mixed plastics. Some recyclers only process one or two types of resin. Therefore, a bale that is supposed to be all PET could be rejected if it is mingled with some other type of plastic in the bale. Prior to China's ban on accepting U.S. post-consumer recycled plastic, a handful of MRFs had advanced facilities and practices to produce high-quality bales. Since the ban, more U.S. MRFs have upgraded their equipment and processes to more thoroughly sort out contaminated materials. However, they remain a tiny fraction of all MRFs in the nation.

Types of Plastic

Different types of resin are commonly identified on packaging by a number 1 through 7 in a triangle made of three arrows. These resin identification codes (RICs) originated in the late 1980s from ASTM and the Plastic Industry Association's predecessor. They were meant to help recyclers sort different types of resin, but today, consumers have started relying on these RICs to identify whether an item is recyclable. However, the question may not be whether the item is recyclable but whether the local facility is able to recycle that item. The RIC is an identifier of the general chemical composition of a product – e.g. "1" identifies PET, "2" identifies High-Density Polyethylene (HDPE) used in products including milk and laundry detergent bottles, "3" identifies Polyvinyl Chloride (PVC) used in products including shrink wrap and construction pipes, and so on.[9] RICs do not necessarily identify the exact chemical composition of a product. Manufacturers of two different brands may design similar packaging with the same RIC, but each container or package may have a slightly different composition. While products with RICs

[9] https://plastics.americanchemistry.com/Plastic-Resin-Codes-PDF/

1, 2, and 5 have established markets for recycling, there are no national standards for processing plastic recycling.

One common technology used for sorting plastics is an optical scan using infrared light to detect what an item is and its chemical composition. While these technologies are working today, advanced screening technologies are needed because manufacturers are increasingly making resins using many different chemical compositions. Additionally, many packaging containers are made of multiple layers of different types of resin. Advanced processing and sorting is needed to better separate plastics for recycling. There are plastics that cannot be mixed together in a crusher or melted down together because their chemical make-up is so different that they will not mix, for example polystyrene and nylon, or because it could cause a chemical reaction or explosion.

Technology and standards are needed at different stages of the plastics recycling ecosystem. In September 2018, the National Institute of Standards and Technology (NIST) awarded a $3.2 million grant to fund the Center for Materials and Manufacturing Sciences being established at Troy University. The Center will focus on polymer and polymer recycling research in areas including analysis, processing, and testing. This Center's research will help support standards development for key areas. The FY 2020 President's Budget request would eliminate support for this program. In addition to NIST, another federal agency supporting plastics recycling research is the Department of Energy (DOE) through its funding of the Reducing EMbodied-Energy And Decreasing Emissions (REMADE) Institute, part of the Manufacturing USA® network. DOE also funds basic and applied research in plastics recycling and bioplastics at universities and national laboratories.

Mechanical Recycling

Most recycling today is done through a process of mechanical recycling. This process can involve sorting, cleaning, cutting, melting and compressing post-consumer and post-industrial plastics into a raw material for making a new product. Some infrastructure is decades old and was not built with the intention of processing today's volumes and types of resin-based products. For example, plastic grocery bags and other films are recyclable, but they have to be sent to a specialized facility and are typically not allowed in curbside recycling. Many well intentioned people throw these bags in their bins anyway. A collaborative industry effort is funding a pilot project in Pennsylvania to be able to sort films from other recyclables in curbside bins.

Chemical Recycling

Chemical recycling, or depolymerization, breaks down a polymer to its building blocks so that the quality is similar to virgin resin that may be used for food packaging or other high-value uses known as upcycling. This is an important research area because more and more items are made from two or more different types of resins, including some food packaging, shipping envelopes, and others products. Chemical recycling enables recyclers to extrude each type of polymer from an item or introduce an element that will make the resins compatible for combined recycling. Additionally, chemical recycling may remove dyes from colored packaging, creating another way to achieve a food quality, clear resin.

Bioplastics

The National Science Foundation, Department of Agriculture, DOE, and other federal agencies support biobased plastics research. Bioplastics offer a non-petroleum based plastic alternative for some applications, such as food films. More research is needed on biodegradability and end of life issues for bioplastics, as well as how they would be incorporated into existing recycling infrastructure.

Other Issues

Data and Common Definitions – More and better quality data is needed regarding plastic recycling. Information is needed regarding what types of plastic are being manufactured, what types of products can be recycled, and how much recycling is actually taking place. In addition, there is no agreement on what the definition of recycling is for the purposes of data collection and analysis, including whether we should count items collected for recycling but are ultimately disposed of in a landfill or incinerated.

Public Education – More efforts are needed to clarify what can be recycled by consumers and how to disseminate this information most effectively. Municipal recycling policies vary from city to city and depend on the availability and affordability of a MRF that can properly sort recyclables; however, more research, development and dissemination of broadly applicable best practices could help address the public education challenges for plastics recycling.