CLOSING THE LOOP: EMERGING TECHNOLOGIES IN PLASTICS RECYCLING

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTEENTH CONGRESS

FIRST SESSION

APRIL 30, 2019

Serial No. 116–13

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PUBLISHING OFFICE

36–152PDF WASHINGTON : 2019

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C O N T E N T S

April 30, 2019

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Appendix II: Additional Material for the Record

CLOSING THE LOOP: EMERGING TECHNOLOGIES IN PLASTICS RECYCLING

TUESDAY, APRIL 30, 2019

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to notice, at 2:20 p.m., in room 2318 of the Rayburn House Office Building, Hon. Haley Stevens [Chairwoman of the Subcommittee] presiding.

**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

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[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.

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[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.

Chairwoman STEVENS. This hearing will come to order. Without objection, the Chair is authorized to declare recess at any time.

Good afternoon, and welcome to this hearing to review the State of plastics recycling technology in the United States. A warm welcome as well to our distinguished group of witnesses. This is going to be an informative and engaging panel, and I am looking forward to hearing your testimony. I'm also particularly excited to welcome Mr. Paul Sincock, a local leader from a city in my district, Michigan's 11th District, who has worked for the city of Plymouth for over 40 years. How special to have your leadership from southeastern Michigan here with us in the United States capital.

It has been a decade since the Science Committee last held a hearing on recycling, and the challenges have only grown. During this hearing, we will examine recycling technologies and the technology gaps that prevent more of our plastics from being recycled, especially in light of China's new policy to ban the import of the most postconsumer recycled—recyclable materials, including plastics, which the U.S. and other developing countries have been shipping there for the past 25 years. While some businesses were selling China clean and well-sorted plastics, others were not. This was cited as a main reason for the ban.

As we'll hear from Mr. Sincock, one of the things I've heard from local leaders in my district are the challenges they are facing in maintaining their recycling programs. As waste management companies are no longer able to sell recyclables to China, they are driving up their pricing to recoup costs, costs that fall squarely on our municipalities and our taxpayers.

In many cases, U.S. cities are being forced to cut, unfortunately, longstanding recycling programs and are instead incinerating recyclables or leaving them in landfills, releasing dangerous emissions. Americans who are trying to do the right thing—our consumers—for our environment, are left unaware that their efforts are for naught.

Yesterday, I wrote a letter to EPA (Environmental Protection Agency) Administrator Andrew Wheeler to express my deep concern that the Federal Government is not doing more to buildup our own recycling and waste management infrastructure to help cities and States with this newfound burden. I would like to at this time submit the letter for the record, without objection.

Plastic, most of which takes hundreds of years to break down naturally, has been a particular problem. We're seeing record amounts of plastic in our water system, including in our Great Lakes, because we don't have the process to take on the volumes of waste that we are creating.

Plastic is unquestionably convenient, and global production of plastic has soared from 2 million tons per year in 1950 to 400 million tons today. Most of our current U.S. recycling infrastructure is decades old and not built to process the amounts of plastic we have today.

Likewise, our recycling policies haven't kept pace with today's plastic use. The last comprehensive Federal law to improve recycling is the *Resource Conservation and Recovery Act of 1976*, before I was born. The most recent publicly available EPA data on the economic impact of the recycling industry is from 2007.

The Department of Commerce never acted on a 2007 GAO (Government Accountability Office) recommendation for the agency to develop a strategy to stimulate the development of domestic recycling markets. Instead, Commerce activity—or actively sought to build international markets. As a result, the U.S. failed to invest in technology and materials to make the recycling process more efficient.

This is a familiar story about crumbling infrastructure, lost industrial capacity, and lack of leadership. However, China's new policy, while in the short term puts us in crisis mode, should also be seen as an opportunity for the longer term, and we need to start now.

Our response should be to reduce and reuse more, but it is not realistic to think we can give up disposable plastic altogether. We urgently need a national strategy to build out our country's recycling infrastructure. It is our opportunity to seize. At this time, we must invest in research and development of sustainable materials and processes, as well as in standards.

A concerted effort will make recycling more cost-effective for our local governments, while making it easier for the public to participate. In doing so, we can inspire a sustainable manufacturing environment, and above all, reduce emissions to keep our planet healthy.

I greatly look forward to today's testimony and discussion. I hope it is just the beginning of this Committee's efforts to contribute to smart solutions in our Nation's recycling challenges. Thank you.

[The prepared statement of Chairwoman Stevens follows:]

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY

Opening Statement

Chairwoman Haley Stevens (D-MI)
of the Subcommittee on Research and Technology

Subcommittee on Research and Technology Hearing:
Closing the Loop: Emerging Technologies in Plastics Recycling
April 30, 2019

Good afternoon and welcome to this hearing to review the state of plastics recycling technology in the United States. A warm welcome as well to our distinguished group of witnesses. This is going to be an informative and engaging panel and I am looking forward to hearing your testimony. I'm particularly excited to welcome Mr. Paul Sincock, a local leader from a city in my district, who has worked for the city of Plymouth for over 40 years.

It has been a decade since the Science Committee last held a hearing on recycling and the challenges have only grown. During this hearing, we will examine recycling technologies and the technology gaps that prevent more of our plastics from being recycled, especially in light of China's new policy to ban the import of most postconsumer recyclable materials, including plastics, which the U.S. and other developing countries have been shipping there for the past 25 years. While some businesses were selling China clean and well sorted plastics, others were not. This was cited as a main reason for the ban.

As we'll hear from Mr. Sincock, one of the things I've heard about from local leaders in my district are the challenges they're facing in maintaining their recycling programs. As waste management companies are no longer able to sell recyclables to China, they are driving up their pricing to recoup costs – costs that fall squarely on our municipalities.

In many cases, U.S. cities are being forced to cut longstanding recycling programs and are instead incinerating recyclables or leaving them in landfills, releasing dangerous emissions. Americans who are trying to do the right thing for our environment are left unaware that their efforts are for naught.

Last week, I wrote a letter to EPA Administrator Andrew Wheeler to express my deep concern that the federal government is not doing more to build up our own recycling and waste management infrastructure to help cities and states with this burden. I would like to submit this letter for the record.

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This is a familiar story about crumbling infrastructure, lost industrial capacity, and lack of leadership. However, China's new policy, while in the short term puts us in crisis mode, should also be seen as an opportunity for the longer term. And we need to start now.

Our first response should be to reduce and reuse more. But it is not realistic to think we can give up disposable plastic altogether. We urgently need a national strategy to build out our country's recycling infrastructure. At the same time, we must invest in research and development of sustainable materials and processes as well as in standards.

A concerted effort will make recycling more cost-effective for our local governments, while making it easier for the public to participate. In doing so, we can inspire a sustainable manufacturing environment, and above all, reduce emissions to save our earth.

I look forward to today's testimony and discussion. I hope it is just the beginning of this Committee's efforts to contribute to smart solutions to our nation's recycling challenges.

Thank you.

Chairwoman STEVENS. And the Chair now recognizes Mr. Baird for an opening statement.

Mr. BAIRD. Well, good afternoon, Chairwoman Stevens, and I appreciate all of you being here with us to testify this afternoon, and I really appreciate the opportunity to have this hearing about Emerging Technologies in Plastics Recycling.

In the 20th century, American scientists led the invention of synthetic plastic materials. These discoveries were transformative. For the first time human manufacturing was not constrained by the limits of nature. The creation of plastic also made material wealth more widespread and obtainable.

Now in the 21st century, we must lead again in the development of new sustainable materials and recycling technologies. Investments in these key areas will ensure a better world for our children and our grandchildren.

The plastics industry is one of the largest manufacturing sectors in the United States. The industry accounted for more than $430 billion in shipments and 989,000 jobs in 2017. My home State of Indiana has the highest concentration of plastics industry workers in the country, producing nearly $20 billion in shipments. We have an opportunity to leverage that expertise to develop a new circular economy for the United States, an economy that produces, recycles, and reuses materials to reduce cost and waste.

We have witnesses today from government, academia, and industry who are working together on those very things to be able to advance them. I look forward to learning from the recycling challenges faced by local communities and the new solutions, including chemical recycling and applying robotics and artificial intelligence to maintain sorting. Innovation in these areas will help the environment and the U.S. economy.

We all want clean rivers, lakes, oceans, and healthier communities. What my constituents don't want are regulations that will raise the cost of energy, food production, construction, and technology. Costly regulations, like those proposed in the Green New Deal, would hurt middle- and working-class Americans the most.

One of the wonderful things about the Science Committee is that we are not a regulatory committee. We are the committee of the future, looking to innovation and to solve problems. I'm looking forward to hearing from those potential solutions today for recycling plastic.

Thank you, Madam Chair, I yield back.

[The prepared statement of Mr. Baird follows:]

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
REPUBLICANS Frank Lucas, Ranking Member

Opening Statement of Research and Technology Subcommittee Ranking Member Jim Baird, PhD

Subcommittee on Research & Technology Hearing - Closing the Loop: Emerging Technologies in Plastics Recycling

April 30, 2019
As prepared for delivery

Good morning Chairwoman Stevens. Thank you for convening today's hearing on Emerging Technologies in Plastics Recycling.

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We have witnesses today from government, academia and industry who are working together on those advances. I look forward to learning more about the recycling challenges faced by local communities, and new solutions including chemical recycling and applying robotics and artificial intelligence to material sorting. Innovation in these areas will help the environment and the U.S. economy.

We all want clean rivers, lakes and oceans and healthier communities. What my constituents don't want are regulations that would raise the cost of energy, food production, construction, and technology.

Costly regulations, like those proposed in the Green New Deal, would hurt middle- and working-class Americans the most.

One of the wonderful things about the Science Committee is that we are not a regulatory committee. We are the committee of the future, looking to innovation to solve problems.

I'm looking forward to hearing some of those potential solutions today for recycling plastic.

Thank you Madam Chair, I yield back.

Chairwoman STEVENS. The Chair now recognizes the Chairwoman of the Full Committee, Ms. Johnson, for an opening statement.

Chairwoman JOHNSON. Thank you very much, Madam Chairwoman, and good afternoon to all. I want to thank you and the Ranking Member for putting together this panel to draw attention to the important issue before us. And welcome to our witnesses.

Plastics have become fundamental to almost every aspect of our lives, from food storage to 3-D printing technology, and have enabled us to make great technological advances. With this progress, however, comes a cost. Some estimates suggest that all Americans dispose of 22 million tons of products that could have been recycled every year. We produce far more plastic than we can properly recycle, domestically and internationally.

The extent of plastics pollution is becoming ever more apparent and more alarming. Just last week, a study found that over 90 percent of the river flood plains in Switzerland, a country with one of the highest recycling rates in the world, were contaminated with microplastics. It is not just mountains and the soil which are subject to plastic contamination. We have all seen pictures of large masses of plastics floating in the oceans and washing up on the beaches around the world. A study in 2015 estimated that 8 million metric tons of plastic end up in the ocean every year. By some estimates, by mid-century, the oceans will contain more plastic waste than fish, ton-for-ton. While there is little research to date, we should be very concerned about the impact on human health from all of this microplastic in our environment and our food chain.

Complicating the challenge is China's ban on our most imported recyclables. As a matter of fact, it's put a couple of businesses in my district out of business. Too many American communities are facing tough decisions about whether they will need to cut back on what they recycle or even whether they can recycle at all.

The news is not all bleak, however. There are a number of promising new technologies and innovations across all steps of the recycling pathway from collection to repurposing. These technologies are being developed through collaborations that span the lifecycle of the material and include both public and private partners. The goals of these efforts are to increase the efficiency and availability of recycling, repurpose more recycled plastics into high-value products, and ultimately, reduce the impact on the environment and human health. These are important efforts with a critical role for many of our Federal science agencies, as we will hear today.

In conclusion, I want to echo a comment by Chairwoman Stevens. As we look to improve recycling technologies, we must step up our efforts to reduce and reuse plastics through better technology and smarter incentives and policies.

I look forward to today's discussion. I yield back the balance of my time.

[The prepared statement of Chairwoman Johnson follows:]

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY

Opening Statement

Chairwoman Eddie Bernice Johnson (D-TX)

Subcommittee on Research and Technology Hearing:
Closing the Loop: Emerging Technologies in Plastics Recycling
April 30, 2019

Good Afternoon, and thank you, Madam Chairwoman for holding this hearing. I want to thank you and the Ranking Member for putting together this panel to draw attention to this important issue. Welcome also to our witnesses, and thank you all for being here with us today.

Plastics have become fundamental to almost all aspects of our lives, from food storage to 3-D printing technology, and have enabled us to make great technological advances. With this progress, however, comes a cost. Some estimates suggest that Americans dispose of 22 million tons of products that could have been recycled every year. We produce far more plastic than we can properly recycle, domestically and internationally.

The extent of plastics pollution is becoming ever more apparent and more alarming. Just last week, a study found that over 90% of the river flood plains in Switzerland, a country with one of the highest recycling rates in the world, were contaminated with microplastics. It is not just mountains and soil which are subject to plastics contamination. We have all seen pictures of large masses of plastics floating in the oceans and washing up on beaches around the world. A study in 2015 estimated that 8 million metric tons of plastic end up in the ocean every year. By some estimates, by mid-century, the oceans will contain more plastic waste than fish, ton-for-ton. While there is little research to date, we should be very concerned about the impact on human health of all of this microplastic in our environment and our food chain.

Complicating this challenge is China's ban on most imported recyclables. Too many American communities are facing tough decisions about whether they will need to cut back on what they recycle or even whether they can recycle at all.

The news is not all bleak, however. There are a number of promising new technologies and innovations across all steps of the recycling pathway from collection to repurposing. These technologies are being developed through collaborations that span the lifecycle of the material and include both public and private partners. The goals of these efforts are to increase the efficiency and availability of recycling, repurpose more recycled plastics into high value products, and ultimately, reduce the impact on the environment and human health. These are important efforts with a critical role for many of our Federal science agencies, as we will hear today.

In conclusion, I want to echo a comment by Chairwoman Stevens. As we look to improve recycling technologies, we must step up our efforts to reduce and reuse plastics through better technology and smarter incentives and policies. I look forward to today's discussion and I yield back.

Chairwoman STEVENS. Thank you, Madam Chairwoman.

If there are any other Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Mr. Lipinski follows:]

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COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
RESEARCH AND TECHNOLOGY, RANKING MEMBER

May 13, 2019

Congressman Lipinski Statement for the Record for Subcommittee on Research and Technology Hearing "Closing the Loop: Emerging Technologies in Plastics Recycling"

Thank you Chairwoman Stevens and Ranking Member Baird for holding this important hearing to examine plastics recycling challenges, and to allow our subcommittee to discuss new and emerging technologies to address these challenges. I would also like to thank the witnesses for providing their testimony and participating in this discussion.

I would like to submit the attached statement to the hearing record, highlighting recycling innovations by America Styrenics LLC, also known as AmSty, which has a facility in my home state of Illinois. AmSty demonstrates how the "Reduce, Reuse, and Recycle" themes discussed at this hearing may be incorporated into industry practice.

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May 8, 2019

Rep. Haley Stevens, Committee Chair
US House of Representatives Science, Space, and Technology Committee
2318 Rayburn House Office Building
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Dear Ms. Stevens and Distinguished Committee Members,

I would like to take this opportunity to enter the following information into the record of the US House Science, Space, and Technology Committee hearing on "Closing the Loop: Emerging Technologies in Plastics Recylcing" that took place on April 30, 2019.

AmSty completely supports the waste hierarchy of Reduce, Reuse, Recycle, Recover, and Dispose. We believe that only by focusing time, resources and investment on the first three (Reduce, Reuse, and Recycle), can we minimize our dependence on the inherently less sustainable final two (Recover and Dispose). As such, I'd like to share our views on the hierarchy as well as several sustainability innovations taking place at AmSty and throughout the greater plastics industry.

Reduce. Whether a company, an organization or an individual, we should all focus on minimizing the amount of material used in our everyday lives. One of the most prevalent examples of materials used daily are disposable food service items which have become a common and significant part of our routine. These items provide great benefits in terms of convenience, hygiene, and reduction in food waste, but, when used needlessly and wastefully, pose a significant sustainability risk to society. Reducing both the use of these items and the amount of materials used in their production is a major focus for both the food service and plastics industries. Products made from polystyrene contribute to reduced material consumption in a couple of very significant ways.

- The unique nature of polystyrene allows the encapsulation of a surprisingly large amount of air within the structure of the packaging to minimize the amount of plastic needed to serve its purpose. Consider the foam cup for example – its composition is 98% air, requiring significantly less energy and water to produce than similar products made from paper. Polystyrene foam requires 50% less energy, 30% less water, and 20% less CO_2 to produce than paper product alternatives.[i] Additionally, the production of certain paper packaging products, such as cups and egg cartons creates 70% more air pollution and 80% more greenhouse gases when compared to polystyrene counterparts[ii]. Additionally, the fact that a paper sleeve and frequently two paper cups are required to keep a hot beverage from burning your hand is a surprisingly egregious and unnecessary waste of natural resources.

- Recent AmSty led innovation in polystyrene production and chemistry can now significantly decrease the amount of resin needed to make items with similar properties to those of higher weight. This "light-weighting" breakthrough technology known as PolyRenew™ High Efficiency Resin allows everyday items like take-home food containers, meat trays, and school lunch trays to use 10 to 15% less material than before with no degradation in performance.

AmSty is serious about reducing the amount of material needed in our everyday lives. We continue to invest in technology, resources, and innovation to support the first step in the waste hierarchy – Reduce.

Reuse. AmSty supports replacement of disposable items with reusable items where efficient, healthy, and value-adding. Both common sense and numerous studies have shown that replacing disposable bottles, containers, and other food service items with reusable products significantly reduces litter and has a positive effect on reducing marine debris. We do not dispute the sound logic of reusable containers; however, we believe that society should remain cautious of increased health risk if reusable products are not cleaned and sanitized between each use. After all, disposable products were originally created to address health and hygiene issues prevalent throughout society. We've all seen signs on water coolers requesting users not to fill reusable bottles due to risks associated with contamination, health and hygiene. Similarly, reusable straws are also susceptible to bacterial growth leading to potential health issues if not properly cleaned and sanitized between uses. AmSty has developed a hybrid concept that combines the safety and convenience of disposable items with the sustainability footprint of reusable items. Our PolyUsable™ process assures food service items are reused one molecule at a time – reassembled through technology in effect recreating the original product. We believe this innovation is a significant step forward in waste hierarchy – Reuse.

Recycle. AmSty's simple mission, to enhance lives through materials and know-how in a responsible and sustainable manner, requires commitment to developing and marketing sustainable products and solutions. We are very demanding and don't believe recyclability equals sustainability unless the recycling process is economically viable. Societal expansion and growth demand both. Additionally, if society must use disposable items, shouldn't they at least be made from the most sustainable, environmentally friendly material available? I've outlined several initiatives and innovations currently underway demonstrating AmSty's commitment to sustainable recycling of polystyrene.

- AmSty has recently formed a joint venture called Regenyx to develop, promote and operate technology converting discarded polystyrene products into liquid feedstock that can be made back into pure, FDA-approved foodservice products without any loss of quality. Regenyx, established earlier this year, assumed operations of the world's largest plastics to feedstock recycling facility in Tigard, Oregon, previously owned by Agilyx. This innovative company is already using polystyrene waste collected from post-consumer Material Recovery Facilities (MRF), drop-offs, and industrial take-back programs as feedstock, proving polystyrene can be economically recycled in a carbon-durable loop. This circular, PolyUsable™, approach is made possible by polystyrene's unique polymer structure. Polystyrene requires a relatively low amount of energy, compared to other plastics, to "unzip" the polymer, transforming it back into its basic styrene form. Once the styrene is purified, it can be easily repolymerized back into clean, functional, and cost-effective polystyrene again and again. This circular approach is analogous to the water-cycle where water freezes and melts on an infinite basis with no loss in properties. Over time, we believe this technology can be applied to other plastic materials and is one of the most significant reasons for focusing on the collection of polystyrene waste as valuable feedstock, rather than banning it.

- The largest challenge for increasing recycled content and access is economic viability of the recycling process. The historic problem with recycled products is that they almost always return at a lower value than their original use. This loss of value is caused by lower purity, lower quality and FDA concerns in food packaging. The PolyUsable™ process uses advanced chemical recycling technology to return recycled material back to the value chain at the same level from which it started. This effectively eliminates access to end-use markets as an obstacle and significantly expands the economic reach of recycling. Recycling in this manner increases recycled content and promotes "In-Kind" recycling, making polystyrene single-use food service items truly PolyUsable™.

- As an industry leader, we want to address various facts and misconceptions about polystyrene foam. It is often overlooked that substitute materials for polystyrene are no better for the environment and, in many cases, are far worse. Consider the paper to-go cup as an example. While the paper appears to be recyclable, the cups are lined with low-density polyethylene (another type of plastic) to make them water tight. While functional, the combination of paper and plastic makes these cups very difficult to recycle.

Polystyrene foam is highly energy efficient and cost effective - unparalleled in its insulative properties to reduce food waste. As an example, the Baltimore City Council attempted to institute a foam foodservice ban in June 2018, which was ultimately vetoed. County Executive Steve Schuh opposed the proposed ban citing its impact to school meal programs and the added cost to the city school district, "The school system serves millions of trays of food. Changing to a new type of food tray would cost an estimated $364,000.[iii]"

- There are a variety of reasons why we should work toward recycling of plastic materials rather than banning them. Banning one material for another simply isn't the best course of action for reducing litter and does nothing to bring us closer to a zero-waste goal. The Plastics industry is committed to litter and waste reduction, particularly from polystyrene products that can be part of the Polyusable™ recycling process. On litter as a whole, it is well established that polystyrene products are only a small part of the overall problem. Banning polystyrene would have minimal impact, not only because of the volumes, but also because difficult to recycle materials like plastic-lined paper cups would be substituted into those applications. Comprehensive collection and recycling of plastic products is the circular solution needed to address the litter and marine debris issue. Steven Stein, principal of the Washington-based Environmental Resources Group shares some helpful insight into the problem of litter. Here's what Stein says in the Los Angeles Times [v]: *"Foodservice containers made of polystyrene are a minor component of litter...The data I have reviewed from L.A. County and nationwide consistently show that litter on our streets and trash in our waterways comprise a broad range of items representing what people typically use in their daily lives. All types of materials are occasionally discarded improperly without regard to the impacts."* He goes on to say that banning foodservice foam containers will not reduce the amount of trash in streets and waterways and banning polystyrene will only result in the substitution products being discarded in exactly the same manner. Stein recommends targeted enforcement of existing litter ordinances by tracking how litter ends up in the streets and storm drains to combat litter, rather than banning the materials which are littered. A study conducted by the Friends of the Los Angeles River confirms these findings. The organization sampled trash from the L.A. River from 2004-2011 which found that foodservice packaging accounted for an average of only 5% of the trash, with a few samples ranging slightly higher [vi]. Unfortunately, polystyrene foam is often perceived as a major component of litter due to its light weight and color even though the data does not support that assertion. Additional supporting data can also be found in an audit performed in San Francisco, examining the litter problem in that city [vii].

- AmSty supports the bold initiatives recently outlined by the American Chemistry Council (ACC) requiring 100% of plastic packaging to be recyclable or recoverable by 2030 and 100% of plastic packaging to be re-used, recycled or recovered by 2040. These milestones ensure all plastic remains sustainable and an important part of the circular economy. Continued innovation in process improvement is needed, but even more critical is investment in recycling infrastructure to deliver a truly circular solution. We believe funding these infrastructure improvements is best handled through 1) Private-public partnerships where companies buy waste directly from municipalities which in turn reinvest the income back into recycling infrastructure; 2) Financial initiatives requiring all participants within the value chain to contribute to ensuring end-of-life solutions for their products; and 3) Increased government investment in recycling infrastructure and corresponding tax incentives for companies making sustainability-based investments.

- Last year the ACC reported that 333 chemical industry projects directly attributed to shale gas and energy advantage in the US have been announced since 2010, cumulatively valued at $202 billion. These massive investments in people, processes, and assets require significant process efficiency to assure safe and reliable operations. At the same time, the industry understands the need to introduce plastic waste as a chemical feedstock into these highly efficient, high volume production units. Despite these challenges, AmSty is now including plastic waste as feedstock at our largest petrochemical facility in St. James, Louisiana. Based on the sheer magnitude of the petrochemical industry, recycled plastic waste will likely only make up a small portion of the feedstock used over the next decade. Correspondingly, recycled content in the final product will also remain a small portion of the output. To date, it is not yet efficient to segregate production between virgin and recycled material at world-scale plants. As an example, let's consider a large integrated facility producing 10 billion pounds of product. If that facility were to incorporate 100 million pounds per year of plastic waste as feedstock, a huge amount by today's standard, the recycled content of the final product would be just 1%. While any amount of recycled content is a good thing, it is difficult to get brand owners and consumers excited about this small of an improvement in sustainability. However, if the producer could get credit for the amount of recycled material actually produced by appropriately applying a common mass balance equation, the producer could theoretically market 100 million pounds of 100% recycled content material. This molecular accounting system would incent companies to invest in sustainability, allow them to continue to run their plants efficiently and safely, while also diverting significant quantities of plastic waste from the landfill. This concept is analogous to how consumers choose to purchase sustainable energy off a non- segregated electrical grid that uses mass balance to appropriately and ethically address the need. Over time, this concept has driven increased investment in and consumption of renewable energy without the complexity and cost of physically segregating the electrons.

AmSty and the rest of the Plastics industry continue to invest billions of dollars to make the concepts, options, and processes described above today's reality. In our view, no other industry has the resources, knowledge, and economic power to fix this global issue, and we take seriously our responsibility to improve society both today and in the future through our focus on waste hierarchy – Recycle.

I want to take this opportunity to thank you and the Committee for reviewing AmSty's position on how polystyrene and the PolyUsable™ process can effectively address waste hierarchy goals and initiatives. We are confident we are on the right path to reduce, reuse, and recycle polystyrene, as well as other plastics, in the most efficient and sustainable manner possible. AmSty remains completely committed to our long-term goal that no polystyrene item ever needs to be landfilled.

Sincerely,

Brad Crocker
President and Chief Executive Officer

[i] Life Cycle Inventory of Foam Polystyrene, Paper-Based, and PLA Foodservice Products – Franklin Associates, Prairie Village, Kansas, 2011
[ii] Paper or Plastic – What's the Greener Choice? – Anne Thompson, 2007
[iii] http://digitaledition.baltimoresun.com/infinity/article_share.aspx?guid=add19994-8af5-4eb9-a0bb-69640aef5e92
[v] Take it from a trash researcher: Banning polystyrene food containers won't do any good – https://www.latimes.com/opinion/opinion-la/la-ol-polystyrene-food-takeout-containers-ban-20170628-story.html – Steven Stein, Los Angeles, 2017
[vi] Friends of Los Angeles River Report – Nicholas Tyack, Los Angeles, 2011
[vii] http://sfenvironment.org/downloads/library/2008_litter_audit.pdf

[The prepared statement of Ms. Bonamici follows:]

Congresswoman Suzanne Bonamici – April 30, 2019
Questions for the Record
Science, Space, and Technology Research and Technology Subcommittee Hearing
Closing the Loop: Emerging Technologies in Plastics Recycling

Thank you Chair Stevens and Ranking Member Baird, and thank you to our witnesses for being here today.

Every minute, the equivalent of a garbage truck full of plastic is dumped into our oceans. According to the United Nations, that's more than eight million tons a year. Plastic bottles, straws, grocery bags, cigarette butts, fishing gear, and abandoned vessels litter the ocean. Currents and atmospheric winds carry floatable marine debris. These movements trap items in debris accumulation zones, also known as garbage patches. A study published in the journal Scientific Reports estimated that the Pacific Garbage Patch is comprised of 1.8 trillion pieces of debris. We still don't know how long it takes for plastic to completely biodegrade. Estimates range from 450 years to never.

Marine debris harms our costal economies, endangers marine life, destroys important marine habitat, propagates invasive species, and creates hazardous conditions for the maritime industry. Tiny pieces of plastic, fiber, fragments, and microbeads also make their way into marine life, blocking digestive tracts, altering growth, and in some cases killing animals and marine organisms.

Marine debris is entirely preventable. But we must support responsible disposal practices. As Co-Chair of the House Oceans Caucus, last year I worked with my colleague Congressman Don Young from Alaska to pass the Save Our Seas Act, a first step to address marine debris. We are currently working with our Senate Oceans Caucus colleagues on a Save Our Seas 2.0.

Question 1: According to a study in Nature Geoscience, earlier this month, researchers in France found thousands of microplastic are airborne and may be polluting the air that we breathe. Dr. Beckham, in your testimony you discuss the pervasive nature of microplastics in our society, from our soil to our food chain. What do we currently know about the effects of microplastics in our ecosystem? What research is needed to better understand the consequences for human health?

Question 2: Dr. Beckham, in your testimony you mention that "emissions from plastics combustion, beyond carbon dioxide, often contain toxic metals...causing yet another potential environmental cleanup problem while simultaneously adding to the amount of carbon dioxide in the atmosphere." How can Congress better support efforts to sustainably break down plastics in the recycling process?

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April 30, 2019

The Honorable Haley Stevens
Chairwoman
Subcommittee on Research & Technology
Science, Space, & Technology Committee
U.S. House of Representatives
2321 Rayburn H.O.B.
Washington, DC 20515

The Honorable Jim Baird
Ranking Member
Subcommittee on Research & Technology
Science, Space, & Technology Committee
U.S. House of Representatives
2321 Rayburn H.O.B.
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Dear Chairwoman Stevens & Ranking Member Baird:

The Portland Cement Association (PCA) is pleased to provide the following statement to the Science, Space, & Technology Subcommittee on Research and Technology in support of your hearing today, *Closing the Loop: Emerging Technologies in Plastics Recycling*. Our membership supports innovative uses for secondary materials like post-industrial, post-commercial, post-consumer plastic, paper, and other materials, which have tremendous energy value. Their use as fuels helps to reduce industrial emissions of greenhouse gases (GHG) and other emissions, limit landfill disposal of materials that can become public health vectors and safety risks, conserve natural resources, and provide low-cost, sustainable fuels.

PCA, founded in 1916, is the premier policy, research, education, and market intelligence organization serving America's cement manufacturers. PCA members represent 93 percent of the United States' cement production capacity and have facilities in all 50 states. Cement and concrete product manufacturing, directly and indirectly, employs approximately 600,000 people in our country, and our collective industries contribute over $100 billion to our economy. Portland cement is the fundamental ingredient in concrete. The Association promotes safety, sustainability, and innovation in all aspects of construction, fosters continuous improvement in cement manufacturing and distribution, and promotes economic growth and sound infrastructure investment.

The cement industry has a long history of safe and efficient use of alternative fuels, ranging from used tires and biomass to a wide variety of secondary and waste materials. Cement kilns are uniquely suited to the safe and efficient use of a wide range of alternative fuels. Cement kilns heat limestone and other raw materials to over 2,700 degrees Fahrenheit during the cement manufacturing process. The high operating temperature and long residence times make cement kilns extremely efficient at combusting any fuel source with high heating value while maintaining emissions at or below the levels from traditional fossil fuels. The final product, cement, is the main component in concrete, a critical component of roads, buildings, water projects, and other forms of resilient infrastructure that are desperately needed at this time. For the cement industry, secondary materials that would otherwise have little market value are valuable commodities, offering a cost-effective and environmentally sustainable alternative to traditional fossil fuels.

The cement industry is constrained by legal barriers through the Resource Conservation and Recovery Act, the Clean Air Act, as interpreted by the courts, and Environmental Protection Agency regulations restricting the use of non-hazardous secondary materials and wastes as fuels. In 2007, the DC Circuit Court of Appeals found that facilities combusting solid waste for energy recovery must be regulated as solid waste incinerators. In response, the EPA issued regulations attempting to clarify when non-hazardous secondary materials would be deemed solid waste when used as fuel for the purposes of energy recovery. In theory, the 2011 Non-Hazardous Secondary Materials Rule should allow for and encourage secondary materials to be used for energy recovery if they met specific legitimacy criteria. In practice, the standards and procedures established under the rule prevent significant amounts of landfilled materials such as plastics, paper, fabrics/fibers, and other secondary materials from being used as fuels, despite their demonstrably lower greenhouse gas and other air emissions. Today, alternative fuels make up only about 15 percent of the fuel used by domestic manufacturers, compared to more than 36 percent in the European Union, including as high as 60 percent in Germany.

The cement industry can beneficially reuse the millions of tons of plastics and other landfilled materials for energy recovery. The cement industry's use of scrap tires provides an illustrative example for beneficially reusing materials traditionally landfilled as fuels. EPA lowered regulatory barriers to using scrap tires as fuel helping the industry to increase its use of tire derived fuel (TDF) from 40 million tires in 2011 to 60 million tires in 2017. TDF serves as excellent fuel for cement kilns as they have high heating value and have demonstrated lower GHG, nitrogen oxide (NOx), sulfur dioxide (SO2), and particulate matter (PM) emissions than traditional fossil fuels. There is a similar opportunity to reuse the millions of tons of plastics discarded into landfills, including the marine debris plastics that could further reduce GHG and other air emissions, promote energy security, and ensure cleaner waters.

Considering the Committee's interest in addressing climate change, we encourage further exploration into ways the EPA can lower barriers for manufacturers to increase their use of alternative fuels. Such actions by Congress would permit:

- beneficial reuse landfilled materials for energy recovery,
- reduced reliance on traditional fossil fuels,
- benefit the environment and public health through lower GHG and air emissions, and
- a decrease in public health and vector risks.

Thank you for your consideration of our comments.

Sincerely,

Rachel Derby
Vice-President, Government Affairs
Portland Cement Association

Chairwoman STEVENS. At this time, I would like to introduce our witnesses. Our first witness is Mr. Paul Sincock. Mr. Sincock is the City Manager for the city of Plymouth, Michigan, located in western Wayne County, Michigan. In this role, Mr. Sincock is the Chief Administrative Officer of the city and is in charge of the day-to-day operations of the city and directs the city's efforts on recycling. Mr. Sincock also took the lead in implementing a pay-as-you-throw trash disposal system in the city and is a regular speaker on the topic of solid waste and recycling programs. He is also one of the first people who brought this problem to my attention.

Our next witness is Dr. Govind Menon. Dr. Menon is the Founding Director of the School of Science and Technology and the Chair of the Department of Chemistry and Physics at Troy University. In 2018, Dr. Menon received a $3.2 million grant from NIST (National Institutes of Standards and Technology), one of the agencies that our Subcommittee proudly has oversight over, to help establish a Center for Materials and Manufacturing Sciences, which will focus on research into polymers and polymer recycling. Dr. Menon has a master's degree and a Ph.D. from Troy University.

After Dr. Menon is Dr. Gregg Beckham. Dr. Beckham is a Senior Research Fellow at the National Renewable Energy Laboratory (NREL). He currently leads and works with an interdisciplinary team of biologists, chemists, and engineers at NREL on conversions of biomass to chemicals and materials and in the area of plastics upcycling. He received his Ph.D. in chemical engineering from MIT.

Our final witness is Mr. Tim Boven. Mr. Boven is currently the Recycling Commercial Director for the Americas within Packaging and Specialty Plastics at Dow. He is responsible for developing new business models and growth strategies that monetize hard-to-recycle plastic streams in the Americas. Thank you for your leadership on that. This includes technologies to enhance mechanical recycling and chemical recycling technologies. He holds a B.S. in engineering from Western Michigan University and an MBA from Central Michigan University.

As our witnesses should know, you will each have 5 minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When you have completed your spoken testimony, we will begin questions. Each Member will have 5 minutes to question the panel.

At this time, we will start with the 5-minute testimony from Mr. Sincock.

**TESTIMONY OF PAUL SINCOCK,
CITY MANAGER, CITY OF PLYMOUTH, MICHIGAN**

Mr. SINCOCK. Thank you, Madam Chairperson. I'm pleased to be here today and honored

[Audio malfunction in hearing room] cycles and to get their materials in proper and acceptable format to the curb to allow our vendors to collect and process that material. We have to be able to do this in a cost-effective manner.

The current market situation does cause us some concern as we move forward on the viability of recycling because of the costs that are going up. Without a viable end market for recyclable goods, the value of recycled goods simply goes down. The cost of collection, sorting, shipping all must be factored into the municipal equation. When the value of collective recyclables goes down, municipal costs go up. When that happens, the local elected officials have the challenge of either increasing the cost of recycling programs and collections or eliminating parts of that program and potentially landfilling recyclable materials.

In my home State of Michigan, recycling ranges from programs not offered to a countywide drop-off site to a regional drop-off site to municipal drop-off sites to curbside programs with a bucket or a bin to curbside programs, which is what we use, is commonly called a trash cart you can put your recyclables in.

If the cost of processing recycling goes up significantly, there may be a point from the municipal perspective where we are forced to make a choice on recycling or eliminating recycling efforts due to cost. Partnerships are key in our program between government, our vendor, residents, and end-users. For example, our vendor provides us with educational materials that we can use and adapt as part of our program to help educate our residents.

From a technology standpoint, our solid waste and recycling collection program is pretty basic for our residents. We provide weekly pickup of solid waste and recyclables. If—they have a brown cart for trash and they have a big 65-gallon cart for recycles as well.

Our mission as a municipality is to help make sure that our residents understand what is acceptable and what is not acceptable as far as the recyclables go. Our municipality alone does not generate enough volume of materials needed to provide the sorting and recycling services at a cost-effective methodology. Fortunately, we're in a region where there are large contractors, and there is enough volume to handle that.

While recycling is the right thing to do, it is also a business, and we must be very aware of the business side of recycling. Some materials have limited end markets. Some materials are changing faster than the capital investment cycle to keep up with the changes, and perhaps future technology will allow us to expand end markets to keep up with the changes in materials.

In our small Michigan municipality, it is our job again to educate our residents on an ongoing basis to ensure that the quality of our recycled goods is clean and acceptable. Municipalities across the country must have cost-effective programs that allow our residents to easily recycle materials rather than throwing them in a landfill. At a minimum, it must be just as easy to recycle something as it is to throw something in the trash. Ideally, it would be easier for the homeowner or resident to recycle a product rather than throw it out.

Thank you very much.

[The prepared statement of Mr. Sincock follows:]

Statement by Mr. Paul J. Sincock

City Manager of Plymouth, Michigan

Before the

Subcommittee on Research and Technology

of the United States House Committee on Science, Space, and Technology

"Closing the Loop: Emerging Technologies in Plastics Recycling"

April 30, 2019

As a small-town City Manager or Chief Administrative Official, along with our administrative team we are responsible to implement the recycling policies of our local elected officials. From an environmental perspective the ability to cost effectively reduce, recycle and reuse products is a positive feature of the community. From a community perspective, offering recycling is wonderful and a source of community pride. From an administrative perspective, our job is to get our residents to get the recycles in a proper and acceptable format from the house to the curb to allow our vendor to collect and process.

We also must understand that recycling is a business and it is affected by various markets and cost centers. While recycling is the "right thing to do," there is an economic side of the equation that needs to be considered. Every recycled product has a value and those values tend to go up and down over the course of time. There also needs to be an "end market" or new product than can be made from the old recycled product. Without a viable end market for the recycled goods, the value of the recycled goods goes down. The cost of collection, sorting and shipping must also be factored into the equation. When the value of collected recycles goes down, the municipal costs go up. When that happens, the local elected officials have the challenge of increasing the cost of recycling collections or eliminate parts of the program and potentially must landfill materials.

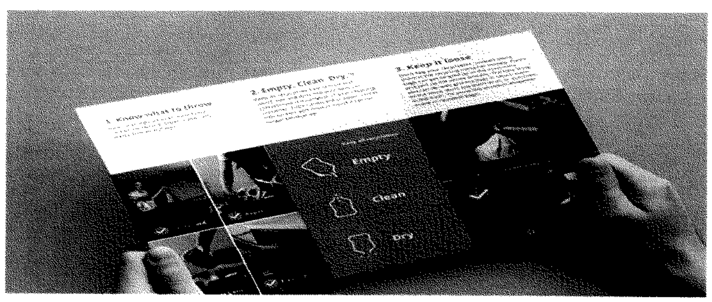
From a municipal perspective there are multitudes of differences nationally in recycling programs. There is no single method that works for every community across the region, state and country. In my home in the State of Michigan; recycling ranges from not offered, to a county wide drop off site, to a regional drop off site, to municipal drop off sites, to curbside programs with a recycle bucket/bin, to curbside programs with what is commonly seen as a trash cart. In my own City of Plymouth, our recycling program has evolved over the years from a staffed drop off center with limited hours, to a bagged system, to a bucket/bin system to the system we currently use which is an automated collection cart program. Our City also operates a bulk leaf collection program, which allows residents to rake fall leaves to the curb and City crews will collect them using claw device on a mini-front end load and then dumping into rear load solid waste truck.

We consider our recycling efforts to be successful and effective, because of our relatively high rates of recycling materials that are collected at the curb and our overall diversion of materials away from landfills. Between our City recycling efforts and municipal composting programs we have diverted away from landfills a 26-year average of 42% of materials collected through curbside solid waste, recycling or bulk leaf pick-ups.

Our local unit of government is still challenged by a variety of factors that goes into our programs. A simple increase in the cost of fuel will make a significant difference in the overall costs of the program. There are multiple trucks and other pieces of equipment that operate in our City in order to provide to timely effective pick up of containerized or bulk materials. A 20-cent increase in fuel costs could trigger fuel subsidy in contractor costs and it increases municipal costs for equipment operations as well. Everything in inter-related when it comes to solid waste and recycling issues. If the cost of processing recycling goes up significantly there may be a point; from the municipal perspective where we are forced to make a choice of collecting recycling or eliminating our recycling efforts due to costs.

In my City; our official Waste Stream Reports filed with the State of Michigan indicate that in 1992 we recycled 393.1 tons of materials or about 10% of our waste stream. In 2018 we recycled 972 tons of material or about 24.7% of our waste stream. During that same period from 1992 to 2018 our pounds of "trash" generated, per day/per person has risen from 2.2 pounds to 2.4 pounds per day/per person.

Our recycling programs would not be successful without the partnership we have with our vendor; Republic Services. Our staff meets regularly with our Municipal Services Manager who keeps us apprised of industry trends and what the future may hold for the solid waste and recycling industry. In addition, our vendor provides us with educational materials that we can adapt and reuse as a part of our efforts to educate our residents.



The vendor provides efficient, timely pick up of our residential recyclables and transports them to a Material Recovery Facility (MRF). Under the terms of our contract with the vendor, they would keep any money generated from the sale of bulk recyclables. However, the company also has the risk of market pressures on recycling and if the value of the bulk product goes down, the company takes on that risk.

In our City, the relationship between the vendor and the municipality has been excellent and we work together as a team to provide a high quality, easy to use system for the consumers and efficient pick up at the curb. We also work in partnership to continue to provide educational materials to our residents to help insure that our recyclables are of high quality with minimal contamination. Our current contract with our vendor is expiring this year. When we bid the contract later this spring, we anticipate having increases in bid costs for recycling services, due to the current trend in markets.

From a technology standpoint, our solid waste and recycling collection program is a pretty basic system for our residents, that provides for weekly pick up of solid waste and recyclables. They have one brown 65-gallon cart with wheels for solid waste (trash) and one blue 65-gallon cart with wheels for their recyclables. Our mission as a municipality is to help make sure that our residents understand what is acceptable and what is not acceptable. We also must work with our residents to properly prepare materials prior to placing them in the recycle cart.

During the summer and fall seasons we also offer compost pick up with a third truck. As previously indicated, we also offer a bulk leaf pick up in the fall by municipal crews. Although, we have expended a lot of time, through education encouraging our residents to use mulching mowers. The lawn care industry has also helped by increasing the technology of modern lawn mower design and current designs do an excellent job of fine cutting grass and leaves to be composted on the lawn itself, rather than being collected. From 2010 to 2018 we have seen our volume of compostable yard waste (grass & leaves) go down from just over 641 tons to 519.5 tons of material.

Through meetings with our vendor we are aware that the end markets for recyclables are demanding product with a significantly lower contamination rates than previously allowed. Probably the best "visual" that I could give you is that we have what we would call the cardboard pizza box and it is a recyclable product in our system and perfectly acceptable. However, the greasy cardboard pizza box is not acceptable. If a couple of greasy pizza boxes end up in the cardboard recycles, then that could contaminate the entire load (most likely a bail) of cardboard and make the value somewhere at or below zero. At that point the vendor must make a choice of holding the material and expend resources on storage or to send the material to the landfill. Therefore, the partnership on education between the vendor and the municipality is so critical and must be on-going for the residents.

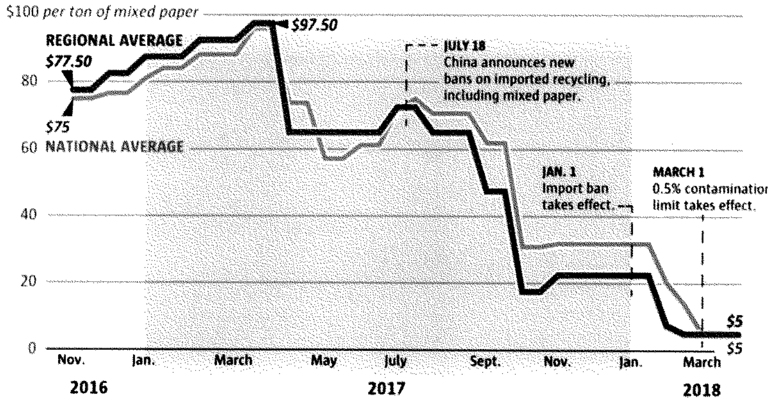
We are currently using a large national corporation as our solid waste and recycling vendor and as previously indicated we have an excellent partnership with the vendor. Republic Services provides collection and processing services in 40 states covering 240 markets with approximately 35,000 employees. This is important from the standpoint that the company will generate the volumes of materials that will allow them to be able to place materials in a variety of different markets to possibly obtain a positive value for recycled goods.

Our municipality alone does not generate the volume of materials needed to provide sorting and recycling services. Our region does provide necessary volumes and the use of private contractors who provides collections from several communities, basically allows us to offer solid waste and recycling services to our residents at a reasonable cost. Again, we anticipate price increases with a new contract later this year as we come to the end of our current five-year contract with the vendor.

While recycling is the "right thing to do" it is also a business and we must be very aware of the business side of recycling. Some materials have limited end markets, some materials are changing faster than the capital investment cycle to keep up with the changes. Perhaps, future technology will allow us to expand end markets and to keep up with changes of materials. I would indicate that in January of this year it was reported to our community that in the plastics industry HDPE had a "good market", but PET had limited end markets. Plastic water bottles have changed significantly over a period of time. Manufactures are "light-weighting" the bottles. While that makes the bottle a little lighter for the purchaser/user of the bottle and it makes shipping slightly lighter, which affects transportation costs. From a recycling standpoint it took 48,000 plastic water bottles to equal one ton of recovered materials in the year 2000, in 2015 it took 92,000 plastic bottles to make that same ton of recovered product and the value of that ton of material is less. We are also now finding that end users of recyclables are requiring significantly less contamination in any load, which is also affecting pricing. The fact that one of the largest importers of recyclables has closed the door on accepting new product, has significantly reduced the value of the products. The Seattle Times using data from RecyclingMarkets.net ran this graphic showing the affects on the value of recyclables in the Pacific Northwest and across North America.

China closes the door, prices crash

The average price paid to recyclers for a ton of mixed paper in the Pacific Northwest and across North America has plummeted in the last year.



Source: RecyclingMarkets.net

EMILY M. ENG / THE SEATTLE TIMES

In our small Michigan municipality, it is our job to educate the residents on an on-going basis to help insure that the quality of our recycled materials is clean and acceptable. Municipalities across the country must have programs that allows our residents to easily recycle materials, rather than throwing them out and landfilling the materials. Municipalities must also provide on-going education for residents to stay informed and to help insure a "quality" recyclable item enters the recycle stream. At a minimum, it must be just as easy to recycle something as it is to throw it out in the trash. Ideally, it would be easier for the homeowner/resident to recycle a product rather than throw it out. Due to the abundance of recycling programs available at home and at the office, we are seeing that people are aware of their personal trash volume and at least in our community look to recycle when possible. You are seeing corporations looking for ways to reduce the use of plastics, including simple things like plastic straws, due mainly in part to consumer awareness. Over the years you have seen food establishments switch from Styrofoam boxes to paper boxes as a part of their environmental efforts and in part, being driven by consumer demands and in some cases governmental requirements.

In my home State of Michigan, we have what is commonly known as a "bottle bill," and basically any carbonated beverage has a charge of 10 cents per bottle or can on the product. This is mandated by State Law. The 10 cents is returned to the consumer when they return the empty bottle or can to a store that sells that product. When the law first took effect, it took a while for consumers to catch on as well as those processing and handling product and the returnables. Technology has helped and now stores are using bar code scanners when returning cans and bottles and it is a basically self-serv program for consumers. Personally, I would rate the Michigan Bottle Bill as a success as it has helped insure that these recyclable items are returned to be recycled.

The Michigan Bottle Bill has resulted in our highways being cleaner as there is less debris from returnable bottles and cans. While the private sector was concerned about the implementation of the Bottle Bill and they may still have many of those concerns today. However, from the consumer stand point; it is an easy to use system and education of consumers is also fairly easy to explain to new residents of the state or visitors to our Great Lakes State.

As a result of the Michigan Bottle Bill; the private sector has changed their methods of collections, implemented some technology and the system is fairly effective. There are still issues with bottles and cans from other states that may have been transported into Michigan. There are still issues with store branded products that are purchased at stores different from the one you are attempting to return the item to. The issue of plastics recycling is significant as we are effectively collecting it, but how do we cost effectively recycle it. There are still some flaws in the system and not every bottle or can is recycled. However, as the law took effect and it took some time to develop methods to efficiently handle products. I am sure that even today; in some areas of our State it is easier to handle and process returnables than it is in other more parts of our State.

The Michigan Bottle Bill is an example of the government and private sector working together to create some positive achievements. The positive of this program is that we have created a significant amount of recyclable material that is being prepared to be recycled. We have closed the loop on the reducing, recycling and reusing products, which is the goal of any recycling program. Although, we still have the issue of plastics. Obviously, metal cans are much easier to recycle and can "close the loop" fairly quickly.

One of the biggest issues related to the "Bottle Bill" that I hear about is the fact that uncarbonated plastic water bottles (just plain water) are NOT included in the required deposit. Again, the program is not 100% effective, it HAS caused more recycling, more work for consumers and those handling products at the retail and wholesale levels. Plastic recycling is an issue that needs to have a cost-effective end market for all of those plastic bottles that we collect to have a totally effective program.

In order to have a successful program of recycling the municipality must help insure that product is recycled and not landfilled. Creditability of recycling rests at all levels of government as each level will need to have their own piece of the "recycling pie." As an example; there is no national bottle bill and deposits on bottles and cans vary from state to state and range from zero to some price established by the state. The local level of government is where recycling starts. The local unit must provide on-going education for its residents in order to have an effective program.

However, in order to have a successful and creditable program there must be viable end markets for the materials collected and hopefully future technology in processing will help create more end markets for the products we collect. In order to Reduce, Recycle and Reuse products there must be an end market for the product to be fully recycled and reused. We must all agree that recycling is the right thing to do, but that it is also a market driven program that depends on technology to develop end uses for collected materials. We must also provide our residents with a program that is easy to follow and allow us to move materials from the house to the curb and ultimately recycled at a reasonable cost.

We must remember that while recycling starts at home, it still must be collected in some fashion, sorted, bailed and ultimately tuned into a new product that allows the reuse of the original container. The recycling process is a journey that starts at home but travels through many hands before becoming a new product. We must insure that we close the "loop" on reducing, recycling and reusing products and we must have an end use for the products that we recycle.

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Experience

March 2001 – Present
City Manager• City of Plymouth, Michigan

July 1, 2018 – June 30, 2019
Rotary International • District Governor for District 6400 with portions of southeast and south-central Michigan as well as Windsor – Essex in Ontario, Canada

2010 – Present
Chairman • Quality Review Committee • Emergent Health Partners – Huron Valley Ambulance

The City Manager is the Chief Administrative Officer of the City and serves at the pleasure of the elected City Commission. The Manager supports budget presentations, business plan reporting to insure compliance with the adopted Strategic Plan of the City, including the one-year tasks. The City Manager in most cases is the public information officer of the City. The Manager also must be familiar with all Department operations.

Served as the Director of Municipal Services for the City of Plymouth and was instrumental in the creation and logistics of implementation of a Pay As You Throw Trash Disposal System in the City. Also, directed the City's efforts on recycling from creating a staffed City drop off location to the current automated cart program. Served as a conference speaker on the topic of Solid Waste and Recycling programs both in Michigan and Ontario.

Also is a frequent speaker on the topic of Customer Service in both the private and public sector and has done presentations both in Michigan and in Canada. In addition, is serving as the Chairman of the Quality Review Committee for Emergent Health Partners – Huron Valley Ambulance.

Leadership

Currently the City Manager for the City of Plymouth with 41 full time employees and approximately the same amount of part time employees. The City of Plymouth is located in southeast Michigan between the City of Detroit and the City of Ann Arbor (home to the University of Michigan). The City of Plymouth is at 25-million-dollar unit of government, with a General Fund Budget of approximately 8.5-million-dollar General Fund.

In addition to duties as City Manager currently serving Rotary International as the District Governor for District 6400. This District area covers 52 Rotary Clubs in two countries, with clubs ranging in size from 15 to 130.

Completed Disney Institute Courses on

- Quality Service
- Employee Engagement
- Leadership Excellence.

Published articles in the Michigan Municipal Review magazine on Municipal Operational topics in areas of Public Safety and Municipal Services.

Served on multiple community Boards, committees and organizations from the Plymouth Symphony to the Plymouth Rotary Foundation.

Past President of the Rotary Club of Plymouth
Past President of the Plymouth Rotary Foundation Board of Directors

Born and raised in the City of Plymouth and has been employed by the City of Plymouth in a full-time capacity for over 40 years. Has served the City as Assistant Director of Recreation and Arena Operations, Grants and Special Events Coordinator, Assistant City Manager, Director of Public Safety, and City Manager since 2001.

Chairwoman STEVENS. And now we will hear from Dr. Menon.

TESTIMONY OF DR. GOVIND MENON, DIRECTOR, SCHOOL OF SCIENCE AND TECHNOLOGY, AND CHAIR, DEPARTMENT OF PHYSICS AND CHEMISTRY, TROY UNIVERSITY

Dr. MENON. Chairwoman Stevens, Ranking Member Baird, and the distinguished Members of the Subcommittee, thank you for including me to this discussion.

Chairwoman STEVENS. Let's just get your mic on. Hold on. We want the world to hear you.

Dr. MENON. So do I. Chairwoman Stevens, Ranking Member Baird, and the distinguished Members of the Subcommittee, thank you for including me in this discussion concerning the recycling of plastics.

I've been asked today to talk about the recently established Center for Materials and Manufacturing Sciences at Troy University, but before I do so, let me begin with a few facts that will place a center such as ours in context.

According to the EPA, currently, the plastics recycling industry is operating below capacity with employment figures comparable with the U.S. automotive industry. Undoubtedly, an increase in supply will increase employment and capital investment.

One of the issues facing the recycling industry is the practical limitations on the large-scale recyclability of the existing types of plastics available in the market. Simple factors like color, odor, strength, and malleability determine the value of recycled plastics. Additionally, environmental concerns behind the breaking down of plastic products loom the industry.

Currently, there is over 200 billion pounds of plastic that can be shaped, extruded, or otherwise transformed into new products. However, at present, the recovery rate for all plastics in the United States is only about 9 percent. Of the two main plastics, PET (polyethylene terephthalate) and HDPE—high-density polyethylene—the United States has a recovery rate of roughly 30 percent. The need for more plastics recycling is made evident and undeniably provides a case for our dedicated center of research.

The establishment of the Center for Materials and Manufacturing Sciences was made possible by a successful $3.2 million grant awarded by NIST. The center will serve as a fully integrated multidisciplinary research facility that will bridge various majors and academic ranks. During the initial phase of establishing the center, one of the primary focuses will be on developing a state-of-the-art laboratory in polymer recycling. This major emphasis will aid to advance capabilities and offer support structure for local and national industries. In the long-term, the center will help address plastics recycling from a holistic perspective with complex issues of collecting, sorting, and cleaning with characterization.

Moreover, the center will assist to engender a well-equipped next-generation workforce to these industries through appropriate course and program offerings. Students trained at the center will participate and be engaged in real-life, real-time industry projects.

In order to glean the larger issues at stake, at its inception, the center hosted a road-mapping session at the recent annual Plastics

Recycling Conference held here in Washington, D.C. I will briefly discuss the three salient points raised by the nearly 200 attendees of the conference workshop.

The primary issue facing the recycling industry is the supply of feedstock. If plastics recycling industry depended on the various States to supply their plant with recyclable feedstock, most plants could only run their facilities for a few days each year.

The second largest issue facing the private sector is access to current technology. As the demand has continued to grow, there is an immediate need for resins with letters of nonobjection from the FDA (Food and Drug Administration). Collection infrastructure, sorting technology, and resin chemistry is limited.

The third and final issue that was raised during the workshop was related to the environmental impact of the recycling process. The point is here—the point here is that the technologies developed must be flexible and incorporate universal utility because the market for material changes rapidly, and materials available today may not be available the next week.

Overall, the above questions make visible a significant lacunae in contemporary research and plastics recycling that can be effectively translated to sustainable goals in the industry. The center will focus on short-, medium-, and long-term issues to be resolved to negate these existing gaps. The specific projects will be carefully selected, prioritized, and undertaken in partnership with industry, community, and other stakeholders.

The nearly zero carbon footprint technology of plastics recycling must be scaled up to meet the demands of global waste reduction. Ultimately, the Center for Materials and Manufacturing Sciences at Troy University will identify, develop, and implement solutions to the problems in contemporary plastics recycling by linking academia, industry, and community. Thank you.

[The prepared statement of Dr. Menon follows:]

BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

Govind K. Menon, Ph. D.
Director, School of Science and Technology
Troy University
Troy, Alabama 36082

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30 April, 2019
Washington, DC

Chairwoman Stevens, and the members of the subcommittee:

Thank you for the opportunity to participate in this seminal discussion today.

The Troy University Board of Trustees approved the creation of a new School of Science and Technology on December 13, 2012. This school, which is comprised of five departments, Biological and Environmental Sciences; Chemistry and Physics; Mathematics; Geospatial Informatics and Computer Science is housed within the College of Arts and Sciences. The mission of the School of Science and Technology is to bring agency to the teaching of sciences, research in pure and applied sciences, and in its relevance to industry.

I am currently a Professor of Physics in the Department of Chemistry and Physics at Troy University. In my 19^{th} year of service, in 2015, I was appointed as the founding director of the School of Science and Technology at Troy University. The desire to establish an academic center related to the recycling of plastics was already brought to my attention during my interview for the position of Director.

I am happy to report that Troy University's School of Science and Technology has recently established a Center for Materials and Manufacturing Sciences (CMMS)[1] at Troy University in Troy, Alabama. The establishment of the Center was made possible by a successful 3.2 million dollar grant awarded by the National Institute of Standards and Technology (NIST). This Center will serve as a fully integrated multi-disciplinary research facility that will bridge various majors and academic ranks. Undergraduate students will be encouraged to enter into research early on in their academic career to develop a sustained and deeper understanding of the field. Faculty researchers and students will form the mainstay for the Center.

[1] Hereafter referred to as Center.

During the initial phase of establishing the Center, one of the primary focuses will be on developing a state-of-the-art laboratory for polymer/plastics recycling. This major emphasis will aid to advance capabilities, and offer support structure for local and national industries involved in the rapidly growing market sector of polymer recycling. In the long term, the Center will help address plastics recycling from a holistic perspective with complex issues of collecting, sorting, and cleaning with characterization—with processing and product development as core competencies. Moreover, the Center will assist to engender a well-equipped next generation workforce to these industries through appropriate course and program offerings. Students trained at the Center will participate and be engaged in real life/real time industry projects. As part of this initiative, Troy University will collaborate with the University of Alabama at Birmingham (UAB) to offer innovative programs in Materials Science and Engineering to Physics and Chemistry students at Troy.

1. Scope

Responding to requests from a local industry, KW Plastics, the School of Science and Technology faculty at Troy University has previously partnered in research concerning core aspects of the recycling of plastics[2]. One of the current issues facing the polymer and recycling industry is the practical limitations on the large scale recyclability of the existing types of plastic containers currently available in the market. Simple factors like color, odor, strength and malleability determine the value of recycled plastics. Additionally, environmental concerns behind the breaking down of plastic products loom the industry. Together with the immediacy to adopt a green lifestyle and the rapidly increasing standards for environmentally friendly materials, the present-day plastic recycling industry has a large demand to fill. Currently, over three hundred million tons of plastics are manufactured across the globe[3]. This provides for a potential market of over two hundred billion pounds of new material that can be shaped, extruded, or otherwise transformed into new plastic products. However, according to

[2] Preliminary research was conducted by our resident Analytical Chemist Dr. Shaoyang Liu on the odors of recycled samples provided by KW Plastics in 2017-2018.
[3] "Earth Day 2018: End Plastic Pollution" www.earthday.org, 2018.

the most recent Municipal Solid Waste Report from the Environmental Protection Agency, at present, the recovery rate for all plastics in the United States is only nine percent [4]. Of the two main plastics, Polyethylene terephthalate (PET) and High-density polyethelene (HDPE), the United States has a recovery rate of only 31 percent and 28 percent respectively[5]. Consequently, KW Plastics, the world's largest plastics recycler, headquartered in Troy, Alabama, has experienced a phenomenal growth in recent years. This is due to proprietary research that has expanded the recovery rate of the stated two plastics that dominate the marketplace. However, this opportunity also comes with challenges to the industry. To expand the application of the recycled materials, customers not only require good mechanical properties, but also demand superior sensory qualities for the recycled plastics. To expand, one of the major concerns of recycled resin is its odor. Due to the microstructure of the feedstock, some recycled materials would hold unpleasant smells. These odors prevent them from being used in products that come in close contact with people, such as food trays, inner parts of vehicles, etc. Thus, even if all the other requirements have been met by the material, the odor will restrict its applicability and hence it's utility.

Clearly, innovation and implementation of new technologies lead to successful manufacturing, and are the key to support long-term competitiveness. To obtain necessary knowledge and appropriate instrumentation to solve this problem, chemists at KW Plastics teamed up with the faculty of School of Science and Technology at Troy University in Troy, Alabama[6]. At present, Troy's faculty have been successful at tackling some of the simpler issues in this field. For instance, one of the research outcomes from the joint study predicted that the unpleasant odors from recycled resin could be caused by a large variety of volatile compounds released from the material[7]. In addition, they observed that due to the huge variation of the feedstock, the odorous volatile compounds changed significantly from batch to batch. To detect these volatile compounds, an advanced chemical analysis technique, gas

[4] "Plastics: Material-Specific Data", *Facts and Figures about Materials, Figures and Recycling*, EPA, 2018.
[5] Doug Clauson, "Modernizing the Resin Identification Code", *ASTM International*,2016.

[6] KW Plastics representative joined the School of Science and Technology advisory council in Fall 2016,
[7] Preliminary research was conducted by our resident Analytical Chemist Dr. Shaoyang Liu on the odors of recycled samples provided by KW Plastics in 2017-2018.

chromatography-mass spectrometry (GC-MS), was employed. By coupling this with an advanced extraction technology, viz. solid phase microextraction (SPME), a sensitive and rapid analysis method was successfully established to monitor the large number of volatile compounds in the recycled resin. This method of analysis provided a critical tool to control/eliminate the odor and improve the product quality. As a result, presently, the chemists at KW Plastics are able to monitor the odorous compounds in every batch of production while implementing strategies to control, and subsequently, regulate the odor inherent in these products. It has also become evident that existing resin chemistry and labeling technology in the field needs improvement[8]. This is a small but relevant example that demonstrates the effectiveness of researchers of School of Science and Technology teaming with local industry to solve pertinent problems in the field, thereby validating the potential of the newly established Center in being a crucial force in addressing demanding issues in the field of polymer recycling.

In order to glean the larger issues at stake, at its inception, the Center hosted a road mapping conference session at the recent annual *Plastics Recycling Conference* held in Washington D.C. I will briefly recapitulate three salient points raised by the nearly 200 attendees of the conference workshop. In the coming years, the Center will focus on tackling these poignant issues. The primary issue facing the recycling industry is the supply of feedstock. If the plastics recycling industry depended on the various states to supply their plant with recyclable feedstock, most plants could only run their facilities for a few days each year. Recycling plants purchase material from municipalities and material recovery facilities (MRFs) throughout North America and continue to explore global possibilities. Studies have proven that U.S. has both the supply and the demand, yet lack of infrastructure limits collection. We are filling American landfills with materials that have proven to have value with domestic markets and demand with domestic manufacturers. Development process that ensure a sustainable recycling practice can divert millions of tons of waste while generating large monetary rewards in revenue (per state) and save private businesses and local

[8] Alexander Tullo, "Innovation is Still Alive in Plastics", *Chemical and Engineering News*, 2018.

governments money in hauling and disposal costs. To a large extent, the collection of recyclable plastics is an issue of awareness. The Center has the advantage of being situated within an academic institution. Awareness begins with education. While Communities and municipalities will have to do their due diligence, the Center will help develop a viable plan that can be deployed at various levels to facilitate the collection of recyclable plastics. Further, the Center will work alongside the numerous plastics recycling organizations in the United States to educate and assist in the recycling process.

The second largest issue facing the private sector is access to current technology. As the demand has continued to grow, there is an immediate need for resins with *Letters of Non Objection* from FDA[9], and resins with technical specifications regarding color and smell. However, most recycling centers operate on very restricted budget. As a result most of the recycling centers cannot upgrade their infrastructure on a sufficiently regular basis. There is also a large need for additional technology surrounding sorting techniques in order to recover more material and supply a quality resin. Currently, there is an unprecedented demand from domestic markets for more types of plastics and a larger demand from end markets. Recyclability is less of an issue but collection infrastructure, sorting technology and resin chemistry is limited. Hence, these technologies offer a large opportunity with significant potential impact. Infrared technology does not read back-packaging and certain labels, which are in fact recyclable but unrecoverable if the product cannot get past the infrared readers. Investment in technology and chemistry could give a boost to more postconsumer resin being used in new applications. Naturally, research and development will play a significant role in the daily activities of the center. I fully expect the Center to extend the existing technologies beyond its current limitations.

The third and final issue that was raised during the workshop was related to the environmental impact of the recycling process. Recycling plastics conserve energy and natural

[9] George Sadler, "Recycling of Polymers for Food Use: A Current Perspective", *The Journal of Physical Chemistry*, 1995.

resources. Recycling is a sustainable solution from manufacturing to waste management. Plastics recycling has nearly a net zero carbon footprint comparable to virgin plastic production. Recycling saves significant energy in comparison with extracting virgin material. Recycling plastics reduces the amount of energy and natural resources (such as water, petroleum and natural) needed to create virgin plastic. According to the American Plastics Council, the production of plastics accounts for 4 percent of U.S. energy consumption, and 70 percent of plastics in the United States are made from domestic natural gas[10]. In addition to energy conservation, recycling plastics save landfill space. We know that plastics do not degrade in the landfill. According to U.S. EPA, recycling one ton of plastic material saves 7.4 cubic yards of landfill space[11].

There are many materials that are readily recyclable, but are not currently collectable in sufficient quantity to make recycling feasible. In those areas, development of additional *quantity-multiplying technologies* would be necessary to make the leap forward. Research is needed in *sorting technologies, cleaning technologies, and waste treatment science* to combat the highly variable and fluid conditions in the reclaimed marketspace. Improvements in cleaning, for example, would allow higher utilization of recycled products in markets where smell or color is a sensitive issue. These problems in recycling are similar to activation energy in the field of chemistry—there are certain obstacles that must be cleared for the reaction to go forward. The obstacles in recycling processing are the quantity of new resources and economical techniques in cleaning and treatment, and clearing either of those can drive the process forward toward higher recycling overall.

The point here is that the technologies developed must be flexible and incorporate universal utility— because the market for material changes rapidly, and materials available today may not be available next week. Technology must then be adaptable to new resources.

[10] "Recycling Plastics Also Reduces the Amount of Energy", *BUS 370, Ashford University*, 2015.
[11] "Volume-to-Weight Conversion Factors" *U.S. Environmental Protection Agency Office of Resource Conservation and Recovery*, April 2016.

In as much as possible, the Center will retain adaptability to feedstock as a core requirement for all the technologies developed.

2. Goals

The Center at Troy University will focus on the recycling of plastics with research considering not only the science involved in recycling plastics but also with the logistics in collecting a larger supply of used plastics. Additionally, it will develop and establish a well-defined standard for the quality of recycled plastics. As mentioned earlier, the use and need for recycling of plastics provide for a rapidly growing market that must be addressed through partnerships with industries, communities, academics, and municipalities. The Center at Troy University will help address this issue through education, training and research. The following are proposed:

2.1 Education and Training

- Develop course curricula that includes polymers and polymer recycling
- Introduce the importance of sustainability in materials in existing courses
- Introduce environmental impact of materials in course materials
- Provide short courses to industry and communities
- As part of this program Troy University will partner with UAB to offer Physics/Chemistry students the opportunity to earn a bachelor in Physics/Chemistry and a bachelor in Materials Science and Engineering through a 3 + 2 program and/or the potential for an accelerated MS degree in Materials Science and Engineering at UAB

2.2 Research and Development

- Establish laboratory capabilities for polymer characterization, testing and processing
- Develop research topics in partnership with industry and municipalities
- Provide equipment and expertise in polymer recycling to help industry solve complex problems
- Act as a one-stop resource for community, industry and academia interested in and involved in polymer recycling

The Center will engage faculty and students across all academic areas to work in an integrated problem-solving environment. Undergraduate students will especially be encouraged to conduct applied research to link theory to applications.

2.3 Equipment, Methods, Infrastructure Development

The intent on the first phase of development will be to primarily develop existing labs to include capabilities in polymer characterization, testing and processing. The bulk of the grant funded by the NIST will be used for the purchase and installation of equipment. The following equipment will be acquired to augment existing capabilities:

2.3.a Thermal Analysis Equipment: Thermal analysis equipment is needed to understand the thermal characteristics on the material for processing and utilizations. The following have already been ordered:

- *Differential Scanning Calorimetry (DSC):* Thermal transitions of a polymer play a major role in how the polymer can be processed and utilized. Glass transition temperature and melt temperature are the starting points for understanding polymers.
- *Thermogravimetric Analyzer (TGA):* A TGA provides analysis of a polymer over a range of temperature up to degradation. The mass loss over time provides understanding on the polymers reaction to temperatures, during processing it is vital to understand thermal limits and degradation of polymers.
- *Rheometer:* Understanding the rheological behavior of a polymer is paramount in understanding processing parameters and methodologies to shape and form the polymer into products.
- *Melt Flow Index (MFI):* Whereas most academics and scientists prefer rheological data, plant processing personnel need the MFI to set processing parameters on their equipment.

The key methods of analysis here include measuring heat capacity, melting point, and transition temperature of polymers. Additionally, investigating the boiling point, thermal stability, oxidation process of recycled plastics will help us gain an understanding of it durability.

2.3.b Mechanical Testing: Mechanical testing equipment is needed to understand the mechanical characteristics of the material for processing and utilizations. The following will be ordered in the current academic year:

- *Universal Testing Frame:* A servo-hydraulic test frame (MTS/Instron or comparable) with environmental capability is needed to provide mechanical properties (tensile, flexure, fatigue, etc.) of processed polymers. An environment chamber will help understand the material behavior under different environmental conditions of heat, etc. This is especially needed to understand limitations of recycled polymers
- *Instrumented impact test machine:* One of the major issues with the recycling of polymers is the degradation of impact properties. There is a need to understand the reduction and how this reduction in properties could be eliminated or minimized.

Measuring material physical properties, including strength, peel force, tear force, springiness, elongation, distension, adhesiveness, and hardness will help understand the range of applicability.

2.3.c Processing Equipment: Processing equipment is needed for machining, compression molding, casting, extrusion and forging. The following are proposed[12]:

- *Shredder:* Plastic products, consumer goods, industrial trim offs, etc. will be in bulk form and size reduction equipment will be needed to re-process the material into flake and/or powder form. The mechanical reduction process is typically used in industry with little understanding on the effects of the polymer microstructure, this will provide an opportunity to further research the effects of mechanical size reduction.
- *Twin Screw Extruder (with cooling and pelletizing capabilities):* The extruder will provide opportunities to re-compound recycled material and add fillers and/or additives to restore desired properties. Segmented screws with options to change shear and mixing zones will be needed for different polymer types. Multiple loss-in-weight feeder systems will accurately dispense additives for compounding. Cooling systems

[12] *Equipment in this category will be prioritized and purchased when needed.*

will be needed for controlled air and/or water cooling depending on the polymer system. Puller and pelletizing unit will be variable speed for controlled extrusion speed and pellet profile.

- *Injection molding unit* (with basic tooling for samples): Injection molding is the most common and widely used method for plastics processing. Most recycled plastics will end up at injection molding plants to be reprocessed into products. It is important to use the same process to evaluate the material for research purposes.

Major processing methods include size reduction, extruding with cooling and pelletizing techniques and injection molding for application development.

3. Proposed Schedule[13]

Year I (current):

- Establish search committee to hire a chief scientist
- Polymer chemist begins collaboration with UAB material science department and formulates a research plan
- Polymer chemist gains familiarity with a large scale polymer lab and associated instrumentation
- Retrofit assigned lab space for thermal analysis instrumentation
- Procure instrumentation for thermal analysis
- Prepare and host a road mapping conference

Year II:

- Install and establish the analysis lab
- Retrofit assigned lab space for Mechanical Testing
- Procure instrumentation for Mechanical Testing
- Polymer chemist engages in active joint research with UAB
- Center engages student scholars in research

[13] Based on the duration of the grant, this is a three-year plan.

- Seek additional funds

Year III:

- Establish and advisory board that includes regional stakeholders
- Install and establish the processing lab
- Research students become an integral part of the Center
- Develop a joint program in material science with UAB
- Develop a clear long term vision
- Begin full scale research at CMMS
- Develop a national database of stakeholders
- Include the logistics of collection technologies into research
- Seek external funds
- Develop plans for long term sustainability for the Center

4. Projected Results

4.1 Resource to Industry, Municipalities and Communities

It is clear from our preliminary analysis that the plastic recycling industry has both environmental and economic benefits that are most often unrealized. On the technical end, the range of issues span from the inconsistency of feed stock to the limiting technology in the sorting process. However, a larger issue remains apropos a cost effective way of procuring feed stock. The need for outreach beyond the state of Alabama will also be a part of the central mission of the Center. The economic sway of a more comprehensive and systematic approach to the gathering and recycling of plastics is only exceeded in scope by its environmental impact.

The Center will be a resource for educating communities, through outreach programs on the economic and environmental benefits of plastics recycling. A more educated community will be a more enlightened partner in the collection and preliminary sorting process. Generally, most sorting facilities are owned and operated by municipalities or their contractors. Diverting plastic material from landfills will be a key result in securing a continuous source of feedstock. Municipalities will realize the long-term economic benefits of the program through increased employment and cost savings in garbage disposal, not to mention the improved environmental impact. The key results of the program will be a facility that local and national industries would access to advance the field of recycled plastics. The Center will be resourced with equipment and expertise to help industry advance to a state-of-the-art facility in plastics recycling. Increasing and promoting the capacity of the recycling industry provides spin-off benefits in increased employment (which rivals the automotive industry in numbers), lower dependence on foreign oil (a precursor for polymers) and offers a valuable resource for other manufactured goods and products with the obvious benefit to the environment. Thus, the model developed by the Center with respect to education, research, industry engagement and the outputs thereof will extend these benefits locally and internationally.

5. Human Resource Development

Troy University is committed to human capital development. The teaching and training of the applied sciences will be an integral part of the mission for the Center. Students from all disciplines will be eligible to work on research projects along with individual faculty advisors. Troy University has already committed the necessary faculty lines to supplement the technical expertise. Also, potential physical space for new laboratories have been identified and assigned as the future location of the Center. By design, the proposed labs at the Center will support regional entrepreneurs and businesses with product development that foster long-term job creation and business expansion. The Center will leverage this engagement and will foster entrepreneurial education and provide opportunities for students interested in starting businesses aligned to the Center's mission.

An advisory board comprising of members from the plastics industry, recycling industry, trade organizations, municipalities, and other agencies together with key personnel from the Center will be formed to help manage, direct and provide oversight to the Center activities. The advisory board will meet semi-annually at Troy and provide direction to the

Center and new avenues for integration into industry and curricula. The advisory board will also guide the assessment plan, questionnaire and survey materials required to monitor the progress of the Center. The board will play a key role in directing the expansion of the Center and its facilities.

The broad concepts of developing the Center, its function and interaction with industry is outlined and proposed above. However, input from industry experts, academics, municipalities, trade organizations, legislators, etc. is needed to ensure the success and viability of the Center.

6. Conclusion

Currently, the plastics recycling industry is operating below capacity with employment figures comparable with the U.S. automotive industry (according to U.S. EPA)[14]. Undoubtedly, an increase in supply will increase employment and capital investment. An increase in recycling will increase tax base, lower energy costs and decrease dependence on foreign sources for oil, manufacturing and consumer goods.

According to the Southeast Recycling Development Council, if Alabama increases its recycling by just 10% more each year, the potential economic impact would be over 1,400 new jobs, over $66 million in personal annual income, and $3 million in annual state tax revenue[15]. This equation could be duplicated throughout the nation. Additionally, the Tennessee Department of Environment and Conservation held a study in 2009 and discovered that Tennessee counties, cities and businesses disposed of approximately 7.6 million tons of solid waste at an average cost of $277 million. If Tennessee had recycled 75% of what was buried in landfills, the state could have captured $882 million in revenue, not including the additional savings in tip fees[16]. Besides, the Georgia Department of Community Affairs estimates that Georgians pay $100 million to landfill roughly $300 million worth of recyclables

[14] "Region 4: Municipal Government Toolkit", *archive.epa.gov*, 2016.
[15] Southeast Recycling Development Council (SERDC) study, 2016.
[16] Quoted by Managing Director of KW plastics during interview, 2016.

each year[17]. The need for plastics recycling is made evident in the above examples, and undeniably provides a case for a dedicated Center of research.

Overall, the above questions and responses make visible significant lacunae in contemporary research in plastic recycling that can be effectively translated to sustainable goals in the industry. The Center will focus on the short, medium and long term issues to be resolved to negate these existing gaps. The specific projects will be carefully selected, prioritized and undertaken in partnership with industry, community and other stakeholders.

Troy University is located in close proximity to KW Plastics—the world's largest plastics recycling company. In the recent years, owing to shortcomings in the private sector, KW Plastics has reached out to the faculty in the School of Science and Technology at Troy University for help in developing advanced capabilities in sorting technology and recycling chemistry. Additionally, the logistics involved in collecting a larger sample of used plastics also remains an open issue for the plastic industry in general. The nearly zero-carbon footprint technology of plastics recycling must be scaled up to meet the demands of global waste reduction. Ultimately, the Center for Materials and Manufacturing Sciences at Troy University will identify, develop and implement solutions to the problems in contemporary plastics industry by linking academia, industry, and community.

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[17] Recycling in Griffin Creates Jobs in Georgia", www.cityofgriffin.gov., 2015.

Govind Menon, Ph. D.
Brief Biography

After completing his schooling in India, Govind Menon moved to the United States in 1997 to pursue an undergraduate degree in Mathematics at Troy University. Subsequently, he joined the Physics Department at the University of Alabama in Birmingham for his master's and doctoral degrees in Physics to specialize in General Relativity. His Ph.D. dissertation focused on developing a non-axisymmetric spacetime that permitted gravitational repulsion. During the last year of his graduate training, Menon procured a lectureship at his alma mater—Troy University. Now, in his twenty third year at the university, he is professor of physics, and chair of the Department of Chemistry and Physics. Recently, Menon was appointed the founding director of the School of Science and Technology at Troy University.

Menon's summer sabbaticals at the Naval Research Lab in Washington D.C. have consumed a large portion of his research efforts in the recent years. He works on the active magnetospheres of supermassive black holes, and along with his collaborator Dr. Charles Dermer (Naval Research Lab), has produced the only known exact analytical solution to a stationary, axis-symmetric, force-free magnetosphere in a Kerr (rotating black hole) background. Their efforts have led to a manuscript entitled *High-Energy Radiation From Black Holes: Gamma Rays, Cosmic Rays and Neutrinos* published by Princeton University Press. When Menon is not working on Physics or spending time with his family, he can be found in his study playing classical guitar.

Chairwoman STEVENS. Dr. Beckham.

TESTIMONY OF DR. GREGG BECKHAM, SENIOR RESEARCH FELLOW, NATIONAL RENEWABLE ENERGY LABORATORY

Dr. BECKHAM. Chairwoman Stevens, Ranking Member Baird, and Members of the Subcommittee, I really appreciate the opportunity to be here with you today to discuss the critical need for plastics recycling and upcycling and how foundational science can contribute to this. It has the potential both to protect our Nation's environment, as well as strengthen the economy.

So briefly today what I'll address is primarily around two questions. One is how do we deal with the plastics that we generate today, and the second is how do we make tomorrow's plastics recyclable by design?

So plastics, as certainly echoed in the opening remarks, are essential to modern life. We rely on them, and they made our lives better. As we all know, though, they're choking our world's oceans, they're killing aquatic and terrestrial life, they're in the air we breathe and the food that we eat. And certainly reducing individual plastic use must be part of the solution, but plastics should not be demonized.

On top of this, today's recycling industry, from my perspective, being mostly mechanical in nature, is a downcycling operation. When you put this PET bottle into the recycling bin, if it is recycled, it's much lower in value because its material properties are compromised, and it will tend to go to things that are lower value like carpet or clothing, which still ultimately end up in the landfill. And so there's a very little—in my opinion, very little economic incentive now to do plastics recycling with the current paradigms we use. Of course, we all know that China has recently banned the imports of plastic waste as well, which is causing massive stress on existing domestic recycling. And so we need to think beyond today's recycling paradigm.

And our ultimate goal, as, again, was echoed in the opening statements, is to develop foundational science that can transition us from a linear flow-through economy where this is sourced from petroleum and put into the trash or the recycling bin and likely is still not recycled but downcycled to an economy that is circular such that this material could stay in continuous use.

And to this end, chemical recycling or the use of catalysts, microbes, or enzymes to break down plastics into building blocks and then build them back up into new, virgin-like materials offers a more sustainable, innovative, and I think profitable approach around which we can completely rebuild and rethink the American recycling industry.

Plastics breakdown is very similar to the breakdown of waste plant material like agricultural residues that you would find from corn stover, for example. Plastics are diffusely distributed just like biomass is. They're costly to recover just like biomass. They're also incredibly durable and hard to break down, just like cellulose is. It's the reason why cows need four stomachs and we don't get any caloric value from celery, for example.

The advent of a lignocellulose-based economy, as all of you know, required sustained investment in science and engineering and technology, and over the last 40 years, there have massive gains in the viability of biomass conversion such that the United States and the world I think is on the cusp of utilizing biomass for renewable fuels, chemicals, and materials. Dealing with plastics, just like with biomass, will require sustained commitment to develop these viable processes.

One obvious option in the case of chemical recycling is to take this PET bottle and convert it back into a PET bottle that has the same properties. This PET bottle could be broken down using chemical catalysts or enzymes into its building blocks and put it back into another bottle like this.

Conversely, and I think more interestingly, there's a potential for the concept of plastics upcycling, so put this into the recycle bin, break it down into building blocks, and then put it into something that has a much longer lifetime and a much higher value. For example, this PET bottle can be turned into building blocks that will go into a composite material in a car. It can go into a wind turbine. It can be made into Kevlar. It could be made into other things like this.

This idea of upcycling or the creation of more valuable product from a waste material I think will incentivize the economics of plastics reclamation, which is really what we ultimately need. And examples like this need to be developed to help stem the flow of plastics into the environment and to landfills.

Second, today, most plastics are made from petroleum-based building blocks with recycling as an afterthought. This is of course unsustainable. Foundational science in the last decade or so, especially funded in the United States has demonstrated an accessible bio-based building block portfolio around which we can source new materials to make bio-based plastics.

At the same time that we're building new plastics, we need to think about how they can be recyclable by design at the end of their life. And in this redesigning new materials from bio-based resources, we should inherently design these materials to be recyclable at the end of their lifetime.

In summary, more research is urgently needed in the concept of plastics upcycling and enabling recyclable-by-design plastics. In the last episode of the Blue Planet II, which some of you may have seen, Sir David Attenborough remarks, quote, "We are at a unique stage in our history. Never before have we had such an awareness of what we're doing to the planet and never before have we had the power to do something about that. Surely we have a responsibility to care for our blue planet. The future of humanity and indeed all life on earth now depends on us." He was talking about the plastics problem in this case.

So in my opinion, dedicated, aggressive, and federally supported R&D investment that harnesses the innovation of the U.S. research community must be brought to bear to deal with today's plastics through the development of chemical recycling of today's plastics, as well as thinking about how to make tomorrow's plastics recyclable by design. Developing processes that can achieve this economic viability should enable the creation of a completely new industry in the United States and enable millions of jobs. Thank you.

[The prepared statement of Dr. Beckham follows:]

Prepared Statement of Dr. Gregg T. Beckham
Senior Research Fellow
National Bioenergy Center
National Renewable Energy Laboratory
For the House Science, Space & Technology Committee
Subcommittee on Research and Technology

April 30, 2019

Chairwoman Stevens, Ranking Member Baird, and members of the Subcommittee, thank you for this exciting opportunity to discuss the critical need for emphasis on plastics reclamation, recycling, and upcycling and how new technology investments have the potential to protect our nation's environment and strengthen our industrial competitiveness.

Introduction

My name is Gregg T. Beckham, and I am currently a Senior Research Fellow in the National Bioenergy Center at the U.S. Department of Energy's (DOE's) National Renewable Energy Laboratory, or NREL, in Golden, Colorado. In 2007, I obtained my Ph.D. at the Massachusetts Institute of Technology and started my research career at NREL almost immediately. I began leading a research group in 2011 focused on using biology, chemistry, and chemical engineering to solve some of the most pressing energy and environmental problems facing our nation. In particular, my group has been focused on developing renewable energy technologies to advance biofuels, biochemicals, and biomaterials sourced from lignocellulosic biomass—the plant matter that is abundant in the United States. This work is done in collaboration with academic institutions throughout the United States and all over the world, other DOE national laboratories, and with industrial partners from startups to large multinational companies.

Broadly speaking, the science and engineering research conducted at NREL, and at many U.S. research institutions and universities, on biomass conversion can readily be applied to overcoming the waste plastics problem. More recently, I have been co-leading a growing international collaborative team focused on employing biomass conversion science and engineering to overcome the global environmental problem of plastics waste. Our goal is to create a more circular materials economy, both nationally and globally, that minimizes waste by keeping materials in continuous use. Many of the scientific concepts developed for biomass conversion are also used for plastics conversion. For example, lignocellulosic biomass, which is derived from agricultural residues and timber waste, is a diffuse, solid, and diverse feedstock that is highly resistant to breakdown and is of relatively low value. Plastics are conceptually quite similar, as I will describe in more detail below.

Overall, these projects and collaborations have provided me with an understanding of how biology, chemistry, and chemical engineering principles can potentially be applied—with increased emphasis and federal investment—to help the United States lead the way in developing robust, industrially relevant solutions to stem this growing environmental crisis of plastics waste and to ultimately enable a more circular materials economy.

I was invited here today to discuss with you the broader needs, opportunities, and challenges for research, development, and deployment in chemical recycling technologies and to highlight how universities, government research laboratories, industry, and local governments can spur innovation in this space and "close the loop" on plastics recycling. Although I will highlight specific examples relevant to my group's work at NREL, the broader lessons and capabilities will be applicable to many of the nation's biologists, chemists, chemical engineers, and experts in related fields. Briefly, we must address two questions: How do we handle the stream of plastics we generate today and how do we design the plastics of tomorrow for recyclability-by-design?

Plastics are creating a global environmental catastrophe

Plastics are everywhere, and they are essential to modern life. Some of the initial plastics were actually developed to avoid the use of ivory and, thus, were motivated by an environmental and conservation perspective. Today, more than 300 million metric tons of plastics are produced each year. Almost all of these are derived from fossil-based resources and ultimately based on byproducts from petroleum refining, ethylene, propylene, and benzene. Humankind uses these versatile, robust materials for myriad things—for example, to keep water clean, prevent infection in hospitals, protect and prolong the life of food, lightweight vehicles and airplanes, and also as fibers in clothing and carpeting, bio-compatible materials for human health, major components in renewable energy and electricity generation and for other applications. Indeed, an amusing experiment that anyone can do is to note every single piece of plastic you touch just as you get ready for work; you will soon get tired of taking notes (probably with a plastic pen). The amount of plastics in our daily lives is simply daunting and something that many of us take for granted. It is undoubtedly the case that plastic materials will continue to be used in various forms for the entirety of the next century. In the developing world, where the middle class is on the rise, the use of plastics will grow.

Given their low cost, extraordinary durability, and utility in so many applications, plastics are also accumulating at alarming rates in the world's landfills. The statistics are truly staggering. Experts have estimated that 8.3 billion metric tons of plastics have been made and approximately 5 billion metric tons have already been discarded, with an abysmal recycling rate of only 600 million metric tons. This is despite the fact that recycling alone can save 40 to 90 percent of the inherent energy in plastics relative to the production of virgin plastics—energy savings, which if harnessed, could result in massive-scale economic advantages. Moreover, many plastics are produced for single-use packaging. Up to 40 percent of all plastics are used for minutes to hours to days in single-use packaging applications, while the estimated time for many plastics to degrade in a landfill is centuries to millennia.

Besides choking landfills, plastics are also entering the environment at increasingly alarming rates, perhaps most strikingly in the world's oceans. It is estimated that over 7 million metric tons of plastics enter the ocean every year, a significant portion of which is in the developing world in coastal regions and through major freshwater entry points into the oceans. From there, plastics enter natural food chains, poisoning sea life from pole to pole through the ingestion of plastics by sea life. To put this into context, 7 million metric tons of plastics per year entering the oceans is the equivalent of a dump truck of plastics entering the ocean per minute, all year round. Based on this statistic, the projected population growth, and the projected upward economic mobility of the global middle class, a survey led by researchers at the University of Georgia estimated that by 2050 there will be more plastic in the ocean than fish by mass. Given the reliance of the planet on the health of the world's oceans, this staggering prediction should give us all pause.

Plastics in the environment are by no means limited to polluting the world's oceans. Microplastics are found far and wide in the soil and in the entirety of the global food chain, polluting what we once considered pristine freshwater bodies, and, as highlighted in a study released just this month, they are carried in the air we breathe. Given the amount of plastics in the food chain, plastics are commonly now found in the human body, with potential toxicological effects that are not yet fully understood. Indeed, it is nearly impossible to read or listen to the news and not hear about this problem. Although plastics currently in the biosphere will likely subsist for centuries and millennia, urgent action on a global scale will be required to stem the tide of plastics that enter our controlled landfills, the natural world, and even our own bodies.

Current recycling infrastructure is failing

Since plastics have come into circulation, various forms of a recycling industry have developed around the world, catalyzed by social pressures, governmental regulations, and in some cases economic motivations. However, nearly all recycling today is mechanical in nature. For example, a water bottle—a common, single-use plastic mostly comprising polyethylene terephthalate (PET, recycling code #1)—when recycled, will typically be sorted from other plastics, have the label and cap removed, be washed, and then chopped into flakes. Depending on the color (clear or green), the reclaimed PET plastic will then be heated up and extruded into a new PET plastic that will typically exhibit compromised material properties relative to virgin, bottle-grade PET. This means that reclaimed, recycled PET will typically go into applications such as polyester carpet or clothing. While this represents a second life for the plastic, the value of the reclaimed PET is significantly lower than that of virgin, bottle-grade PET, and in many cases, the plastic will still ultimately end up in a landfill. Thus, most recycling of this nature can be thought of as "downcycling."

Beyond this, China's passage of their "National Sword" policy banned the imports of most waste plastics from North America and the European Union into that nation. Many of the "recycled" plastics in the United States were considered and counted as "recycled" before 2018 if they were sent to China. The passage of the National Sword policy is causing overflows and massive stress on the existing, domestic supply chains. While a major upset in the flow of reclaimed plastics, this policy also presents a significant opportunity for the United States (and more broadly, many countries in the developed world) to rethink and reinvent the recycling value and supply chain toward a more circular materials economy.

Recycling and upcycling technologies provide potential solutions

As noted above, plastics recycling today is mostly mechanical. Alternative strategies for recovering and reclaiming value from plastics should be examined as soon as possible to address the problem of dealing with today's waste plastics. For example, some countries, such as Sweden and Austria, already reclaim and burn a significant amount of the waste plastics generated. Energy recovery from waste plastics, in many cases, is able to circumvent the need for sorting heterogeneous materials from one another and is a cost-effective strategy. Yet in an era of cheap natural gas and renewable electrons coming onto the grid, energy recovery from plastics represents a baseline and likely a non-sustainable means to recover value from plastics. In many regions of the United States, this will be little better than current mechanical recycling or simply landfilling plastics. Moreover, emissions from plastics combustion, beyond carbon dioxide, often contain toxic metals resulting from specific polymerization catalysts, causing yet another potential environmental cleanup problem while simultaneously adding to the amount of carbon dioxide in the atmosphere.

Instead, the use of chemical recycling—using catalysts to break plastics down to their building blocks and build them back into new, virgin-like materials—offers a more sustainable, innovative, and profitable approach around which we can completely rebuild the American recycling industry. Let's address several aspects of what this could look like.

First, why is chemical recycling not already used today? As mentioned earlier, the breakdown of plastics is similar to the breakdown of lignocellulosic biomass. Especially in consumer applications like packaging, plastics are diffusely distributed and often are costly to recover. They are similar to agricultural residues produced on American farmland. Plastics are also incredibly durable and hard to break back down to their building blocks, just like cellulose is in plants. The genesis and continued development of plastic materials almost universally focuses only on "during lifetime" properties, with end-of-life considerations being an afterthought. Thus, plastics are inherently hard to break down and existing approaches to do so are, for the most part, not yet commercial. Drawing on the parallels to biomass conversion, the advent of a lignocellulosic-based economy has required sustained and continued investment in the scientific and engineering enterprises, and over the last 40 years, massive gains in efficiency, process designs, and economic viability of biomass conversion now has the United States and the world on the cusp of utilizing biomass as a foundation for renewable fuels, chemicals, and materials. The stubborn problem of today's plastics, like lignocellulosic biomass, will require sustained commitment to develop viable processes, but the urgency of this problem is clear.

Chemical recycling can be envisioned in many variations, and the type of process design ultimately employed will depend on many factors, including the type of plastic being chemically processed. For example, PET (recycling code #1) exhibits a very different chemical structure from polyethylene (recycling codes #2 and #4, depending on the form) and polypropylene (recycling code #5), and, thus, will require significantly different types of processes to be developed. The types of catalysts and processing conditions used in chemical recycling will likely vary significantly also based on the type of plastic being targeted. Ideally, chemical recycling processes will be able to handle mixed waste plastic streams, and the ability of a process to selectively extract one building block from mixed plastics streams will help avoid upstream sorting costs in a process—a key driver for process viability and robustness. Given the ability to develop new processes from a completely fresh perspective, adherence to the principles of green chemistry and green engineering should be followed and designed into theoretical process concepts.

New developments in catalysis to break down plastics will certainly be required. Thus, the development of robust, scalable, economically viable processes will require advances in chemical catalysis and related fields. Engagement with industry and formation of key partnerships will be essential to ensure the viability of catalytic approaches. Chemical recycling may also include biological elements as well, and indeed, the United States is a world leader in the development of advanced industrial biotechnology. This may include elements such as engineered or evolved enzymes to break down plastics, or the use of engineered microbes to break down plastics and turn the deconstruction products into new building blocks. As an example, NREL and an international team recently engineered a natural enzyme for improved PET biodegradation, and we are working now with a large group of collaborators in the United States and Europe to find even better enzymes that can operate at much higher temperatures as would be needed for industrial utility. We have also engineered a microbe to be able to produce enzymes that break down plastics and then convert the deconstruction products into higher-value materials, such as composite materials for snowboards.

Regardless of the approach for chemical plastics upcycling, scale-up will be a critical component of the research and development in this space. A potential advantage for plastics, relative to biomass, is that many places in the United States already have reclamation facilities with infrastructure in place to collect and process plastics in centralized facilities. How chemical recycling links to the current recycling infrastructure will be a key consideration.

Another major question in chemical recycling is: What do we do with the breakdown products? Among several, one obvious and oft-cited option is to use chemical recycling to break down a plastic and turn it back into the same exact plastic with virgin-like materials properties. This would then ideally result in a closed-loop circular materials flow. For example, IBM has developed an innovative chemical recycling process where they can break PET down to building blocks that can be reprocessed into PET bottles with properties akin to virgin PET bottles for carbonated beverages or water. For processes like this, economics will be a key driver in terms of whether the cost for chemical recycling makes sense relative to buying virgin plastics that have never been used in an application before.

Conversely, instead of having a closed-loop cycle for a single plastic, another option in chemical recycling is the concept of upcycling. Upcycling is the creation of a more valuable product from a waste material. In the same example, perhaps the breakdown products from a PET bottle depolymerization process could go into a higher-value, longer-lifetime material, instead of being put back into the PET supply chain. If the upcycled product has more value than the reclaimed and recycled plastic, this may be an early and easier way to produce market pull for reclaiming and breaking down plastics using chemical recycling. Several key elements must be considered here, including: Does the upcycled material have any inherent advantage over making the same material from virgin sources? For example, if an upcycled material can more easily and more cheaply be made from virgin building blocks derived from petroleum, it will be challenging to create an economic incentive for upcycling.

Another key consideration in plastics upcycling is: What is the market size for the upcycled material? For example, if PET is being converted into a composite that could be used as a car part, how does the demand in scale align with that of PET bottles that can be reclaimed? If the market size is considerably smaller, then multiple upcycling solutions will likely need to be developed to justify the reclamation of waste plastics. In my group at NREL, for instance, we have developed a robust process to convert PET plastic found in single-use water bottles into high-strength composite materials that could be used in high-performance applications like in a wind turbine blade or vehicle parts. The selling price of reclaimed PET is between $0.31 and $0.51 per pound, whereas composite materials like we made sell for around $2.50 per pound, representing a considerable upcycling potential. Examples like this will need to be developed and scaled in collaboration with industry to make these ideas into a reality that helps stem the flow of plastics into the environment and also incentivizes the economics of reclamation.

Regardless of what kind of processes are developed, judicious techno-economic analysis and life-cycle assessment must be a key part of the research portfolio. Doing these kinds of analyses "early and often" can best inform the research community as to the main research areas to focus on to be most impactful. These kinds of tools are universally applied in the industrial chemical processing fields, and they will be critical for the development of a new recycling and upcycling industry based on chemical recycling. In addition, resource assessments will be another critical component of this endeavor. Identifying and understanding the current supply chains, where plastics are collected, and where they are currently recycled will help industry identify new opportunities and existing reclamation infrastructure for investment into chemical recycling technologies.

Transforming the plastics of tomorrow to be recyclable-by-design

Today, most plastics are made from petroleum-based building blocks with recycling as an afterthought relative to lifetime performance and application. This is undoubtedly an unsustainable approach for the long-term health of the nation and the planet. Beyond developing robust chemical recycling and upcycling strategies that deal with the plastics we make now, we also urgently need a transition to sustainably sourced building blocks for plastics, and we need to simultaneously develop plastics that are recyclable-by-design. This will require a fundamental shift in our materials economy.

In terms of new building blocks, research done in the United States and globally in the last two decades has identified a large portfolio of accessible bio-based building blocks that can be derived from waste agricultural residues, waste wood from the timber industry, or produced from dedicated energy crops. Similar building blocks can be made from algae or waste organic materials (e.g., food waste) for producing similar new building blocks. Work from our group at NREL, for example, has produced completely new building block molecules that can go into high-value performance materials such as improved nylons for automotive applications. As another example, work from the Center for Biorenewable Chemicals, led from Iowa State University, also developed a range of new bio-based chemicals that can be leveraged for new plastics applications.

The sourcing of new building blocks for materials from bio-based resources is timely and critically needed. While thinking about redesigning new materials from bio-based resources, we also should inherently design these materials to be recyclable-by-design, not as an afterthought. For example, separate works from IBM, Lawrence Berkeley National Laboratory, and Colorado State University, among others, have developed materials that can serve in the place of petroleum-sourced plastics today but can also be infinitely recycled. The ability, for example, to recycle a computer case into its building blocks easily and chemically could then enable turning that plastic into something completely different, such as a car panel. Innovation in this space, namely the combination of renewably sourced building blocks and plastics that are recyclable-by-design will solve the problem of what to do about "tomorrow's" plastics. Further research and innovation are desperately needed in this space, especially in collaboration with industry, academia, and government research institutions.

More research is urgently needed in plastics

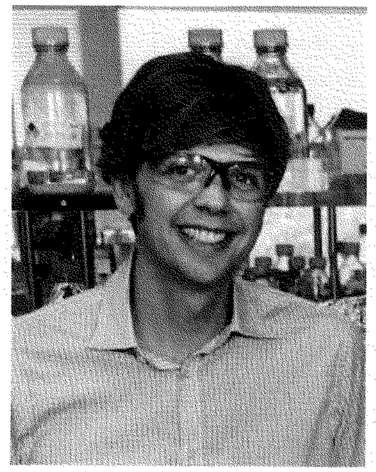
In Episode 7 of the BBC series Blue Planet II, Sir David Attenborough remarked:

> "We are at a unique stage in our history. Never before have we had such an awareness of what we are doing to the planet, and never before have we had the power to do something about that. Surely, we have a responsibility to care for our blue planet. The future of humanity and, indeed, all life on Earth, now depends on us."

This is absolutely the case with the plastics pollution problem. These versatile materials are now choking the world's oceans, killing aquatic and terrestrial life, and in the air we breathe and the food we eat. While reducing our individual plastic use, especially single-use packaging, must be part of the solution, plastic materials are truly useful and provide benefits to many aspects of modern life. This means plastics will not go away anytime soon.

Dedicated investment that harnesses the innovation of the United States research community needs to be applied to dealing with today's plastics through both the development of chemical recycling and re-engineering tomorrow's plastics to be recyclable-by-design. Developing robust processes that can reach economic viability rapidly would enable creation of a completely new industry in the United States and result in millions of jobs. This would also establish the United States as a world leader to solve this global-scale problem.

In a 2017 paper, Roland Geyer wrote that: "without a well-designed and tailor-made management strategy for end-of-life plastics, humans are conducting a singular uncontrolled experiment on a global scale, in which billions of metric tons of material will accumulate across all major terrestrial and aquatic ecosystems on the planet." Aggressive federally supported R&D programs in this area will maximize the nation's economic and environmental benefits, for decades to come.



Gregg T. Beckham is a Senior Research Fellow at NREL. He received his PhD in Chemical Engineering at MIT in 2007. He currently leads and works with an interdisciplinary team of biologists, chemists, and engineers at NREL on conversion of biomass to chemicals and materials and in the area of plastics upcycling. He has published 163 peer-reviewed articles since 2007 and was awarded the ACS OpenEye Outstanding Junior Faculty Award, the AIChE Computational Science and Engineering Forum Young Investigator Award, the *ACS Sustainable Chemistry and Engineering* Lectureship, the SIMB Young Investigator Award, an R&D100 Award, and the Beilby Medal and Prize. He is on the Editorial Board of the*Journal of Biological Chemistry* and the Editorial Advisory Board of *Microbial Biotechnology* and *ACS Sustainable Chemistry and Engineering.* He is also the founding chair of the Lignin Gordon Research Conference.

Chairwoman STEVENS. Mr. Boven.

TESTIMONY OF TIM BOVEN, RECYCLING COMMERCIAL DIRECTOR, PACKAGING AND SPECIALTY PLASTICS, DOW

Mr. BOVEN. Chairwoman Stevens, Ranking Member Baird, Members of the Subcommittee, it's my privilege to address you on the topic of "Closing the Loop: Emerging Technologies in Plastic Recycling." My name is Tim Boven. I am the Recycling Commercial Director at Dow in our Packaging and Specialty Plastics business. My organization is responsible for business solutions that enable a circular economy.

Right now, what's been said, we live in primarily a linear economy where the goods we use every day are manufactured from raw materials, sold, used, and then discarded. Applying the principles of circular economy will allow us to optimize resources to minimize the extraction of new raw materials and ultimately reduce the amount of waste going to landfills.

Recycling is foundational for circularity, and it's good for the economy. Investment in mechanical and chemical recycling will spur domestic investment supporting business growth. If widely adopted, advanced recycling processes could result in growth in new U.S. jobs and economic output. Dow believes plastics are too valuable to be lost as waste, and as such, innovation is needed to retain its value.

Plastics provided many benefits to society, including reducing food waste, improving energy efficiency, reducing material usage, and improving functionality. What society needs and where the industry is now focusing is on effective recycling solutions that retain the value of plastic after its initial use.

Collection is a key step in the recycling process. If the material is not collected effectively, it cannot be recycled. The U.S. recycling system is highly fragmented and variable, resulting in unequal access and confusion. The challenge equates to high contamination levels in collected recycling. Much of the U.S. has a single-stream collection with sorting left to material recovery facilities, or MRFs. Many MRFs are privately owned, and their capabilities vary widely. Most were designed for paper, glass, and metal. Technology and process improvements are needed in this space to improve the quality and consistency of the plastic coming from these facilities.

Once we have collected it, we can recycle it. Plastics can often be much more challenging to recycle than other materials because of its low density and wide range of plastics collected, which may be incompatible. Innovation is needed to improve the ability of equipment to sort and process hard-to-recycle materials.

Two terms commonly used to describe plastic recycling are mechanical recycling and chemical or feedstock recycling. Traditional mechanical recycling is an excellent first step in getting the value from used plastic and has environmental benefits. However, mechanical recycling has a significant limitation in the end-product performance and is only suitable for a limited number of high-volume applications. It is extremely difficult to remove all the contaminants such as dirt, inks, fibers, adhesives, et cetera. All are included in the recycling stream. All impact performance.

Dow is a supporting innovation in mechanical recycling through application development, high-performance material development, allowing for the incorporation of PCR (post-consumer recycled plastic), compatibilization technology to minimize contamination. Even with these advances, mechanical recycling of all plastics is a significant challenge, particularly in high-end applications like those that require FDA approval.

These challenges require innovation that cannot be addressed with processes like feedstock recycling. Feedstock recycling is an advanced recycling process of depolymerizing a plastic back to its original building blocks where it can be then introduced into the front end of the polymer manufacturing process. This process is very similar to paper recycling where it's taken back to fiber. Feedstock recycling has the potential to produce recycled plastic with virgin-like performance capable of being used in the most stringent applications. Dow is actively researching plastic conversion processes of pyrolysis and gasification. We have projects ranging from process technology through the effective conversion to plastic.

Increasing recycling rates and expanding the materials collected will not happen on its own, and there are important steps Congress can take to enable growth in this sector. This includes support on uniform definitions on recycling so that new technology is not precluded, standards for mass-balance accounting to certify recycled plastic content, recycling infrastructure funding, and to support in the development of new end markets for recycled plastic. I've expanded on these topics in my written statement.

In conclusion, thank you for your time and the opportunity to testify on this important topic. We believe the public and private sectors can partner together to advance innovation and accelerate recycling. Dow looks forward to working with Congress on these issues and answering any questions the Committee may have.

[The prepared statement of Mr. Boven follows:]

Testimony of Tim J. Boven
Recycling Commercial Director for the Americas, Packaging & Specialty Plastics,
Dow
Before the Subcommittee on Research & Technology
Committee on Science, Space and Technology
U.S. House of Representatives
Closing the Loop: Emerging Technologies in Plastic Recycling
April 30, 2019

Introduction

Chairwoman Stevens and Ranking Member Baird, and members of the Subcommittee, it is my privilege to address you on the topic of *"Closing the Loop: Emerging Technologies in Plastic Recycling."* My Name is Tim Boven, and I am the Recycling Commercial Director for the Americas for Dow's Packaging and Specialty Plastics business. Dow is a leading global producer of polyolefin plastics. My organization is responsible for driving business solutions that enable a circular economy. I have 22 years of experience with Dow in a wide range of roles ranging from R&D, Thermoplastic Technical Service and Development, Sales and Marketing, Supply Chain, and several Business leadership positions. In my current role I have accountability for Dow's recycling platform that combines material science and application technology to improve plastic circularity. Dow has one of the strongest and broadest toolkits in the industry, with robust technology, asset integration, scale and competitive capabilities that enable us to address complex global issues. All of this enables Dow to deliver on our commitment to support plastic circularity.

Value Proposition to Advancing a Circular Economy

Right now, we live primarily in a linear economy where the goods we use every day are manufactured from raw materials, sold, used, and then discarded as waste. Dow is engaged in the transition from a linear economy to one that redesigns, recycles, reuses, and remanufactures to keep materials in their highest value use for as long as possible. As a result, we will preserve our resources in a "circular economy" making the most of our natural resources. Applying the principles of a circular economy will allow us to optimize the use and reuse of resources to minimize the extraction of new raw materials and ultimately reduce the amount of waste that goes into landfills.

Recycling is foundational for circularity and is good for the Economy. According to the report, "Economic Impact of Advanced Plastics Recycling and Recovery Facilities in the U.S.," if widely adopted, advanced recycling processes could result in nearly forty thousand direct and indirect U.S. jobs, as much as $2.2 billion in annual payroll, and another $9.9 billion in direct and indirect economic output.[1] Dow believes that manufacturing is the lifeblood of U.S. economic growth and strongly supports the subject of today's hearing. Investment in mechanical and chemical recycling will spur domestic investment and US jobs, while supporting business growth and the circular economy. Innovation in advanced recycling is important to the US manufacturing sector and has the potential to positively address many of the challenges facing this country including maintaining technology leadership and promoting global competitiveness.

[1] https://plastics.americanchemistry.com/Economic-Impact-of-Advanced-Plastics-Recycling-and-Recovery-Facilities-in-the-United-States.pdf

Dow's 2025 Sustainability Goals

In 2015, Dow embarked on its third and most ambitious set of 10-year sustainability goals – the 2025 Sustainability Goals. Dow's sustainability journey has evolved from focusing on operational efficiency (footprint), to product solutions to world challenges (handprint), to recognizing that only through collaboration can we join others to accelerate the progress toward a sustainable planet (blueprint). The 2025 goals are centered around building blueprints for a sustainable planet, which are aligned to the UN Sustainable Development Goals and integrate public policy solutions, science and technology, and value chain innovation. The aim is to build solutions between government, business and society that generate shared values and are long lasting, scalable and transformative. We know there are others who share our blueprint vision, and we want to join existing conversations and convene new ones on how we as companies and organizations can accelerate sustainable practices through collaboration.

Dow's 2025 goals are designed to harness Dow's innovation strengths, global reach and the passion of our employees to expand the Company's impact around the world, driving unprecedented collaborations to develop societal blueprints that will facilitate the transition to a sustainable planet and society. Our 2025 sustainability goals include:

- Leading the Blueprint - Dow leads in developing societal blueprints that integrate public policy solutions, science and technology, and value chain innovation to facilitate the transition to a sustainable planet and society.
- Advancing a Circular Economy - Dow advances a circular economy by delivering solutions to close the resource loops in key markets.
- Safe Materials for a Sustainable Planet - We envision a future where every material we bring to market is sustainable for our people and our planet.
- World-Leading Operations Performance - Dow maintains world-leading operations performance in natural resource efficiency, environment, health and safety.
- Delivering Breakthrough Innovations - Dow delivers breakthrough sustainable chemistry innovations that advance the well-being of humanity.
- Valuing Nature - Dow applies a business decision process that values nature, which will deliver business value and natural capital value through projects that are good for business and better for ecosystems.
- Engaging for Impact: Communities, Employees, Customers - Dow people worldwide directly apply their passion and expertise to advance the well-being of people and the planet. To achieve these bold and aggressive sustainability targets, Dow is harnessing its innovation strengths, global reach and dedicated employee population.

With these goals, Dow has committed to helping facilitate the world's transition to a circular economy, through innovation and collaboration, where waste and pollution are designed out of new products and services. Our goal is to advance a circular economy by delivering solutions to close the resource loops in key markets, where we maximize the utility of existing molecules through recycling and reuse.

Opportunities in the Plastic Circular Economy

Dow believes plastic is too valuable to be lost as waste and as such innovation is needed to retain its value. Plastics offer sustainability benefits over other readily available alternatives in many applications. For example, plastic packaging typically has four to seven times fewer greenhouse gas emissions compared to alternative packaging materials.[2] The sustainability footprint of plastic is one of the key drivers of its rapid growth over the last few decades. Plastics provide many benefits including reducing food waste, improving energy efficiency, reducing material usage, and improving functionality, all at a lower cost. What society needs and where the industry is now focusing is on effective recycling solutions that retain the value of plastic after initial use.

Since plastics are relatively new compared to alternative materials such as paper, glass, and metal, and are made with relatively little material, there has been less focus on recycling solutions. Much of the recycling infrastructure in the U.S. was built around fiber, metal and glass. We must do a better job of capturing the residual value of plastics after initial use so that value is not lost through disposal in a landfill. To this end, we are engaged in numerous initiatives to "close the loop" and reduce the amount of plastic that ends up in the environment or is lost to landfill.

We must work to capture and reuse plastic by scaling investments in collection, waste management, recycling technologies, and new end use markets for recycled plastics. In order to do this, it will be critical that solutions are designed for lowest environmental impact, with sufficient infrastructure to collect, technology to process, and delivered to markets that create new value for items that were once considered only disposable.

Collection and Sortation Challenges in the US

Collection is a key step in the recycling process. If material is not effectively collected it cannot be recycled. Dow, along with many other companies and individuals, has partnered with The Recycling Partnership to help improve education and collection through funding projects that expand recycling access and improve the quality of the collected stream.

The U.S. recycling system is highly fragmented and variable, resulting in unequal access and confusion. In addition, much of the material that is collected and sorted in the U.S. was historically sold into the Chinese market for processing and re-use. Since China implemented new restrictions on imports of material for recycling, local U.S. facilities have struggled finding markets for the sorted material. This challenge is growing as other countries institute similar import restrictions. When recyclers lack profitable end markets domestically and internationally, they are not motivated to increase collection or invest in upgraded equipment. This can result in reduced collection, increased landfill use, and increased cost to residents and municipalities.

This challenge is exacerbated by high contamination levels in the material collected for recycling. Much of the U.S. has single stream collection, with sorting left to material recovery facilities (MRFs). Many MRFs are privately owned and have widely varying sorting capabilities. Technology and process improvements are needed in this space to improve the quality and consistency of the material sorted and baled.

Plastic Recycling Processes

Plastic recycling is the process of recovering scrap or used plastic and reprocessing it into beneficial products. It is the foundation for a plastic circular economy, particularly as most plastic does not naturally biodegrade in the environment. Plastic can often be more challenging

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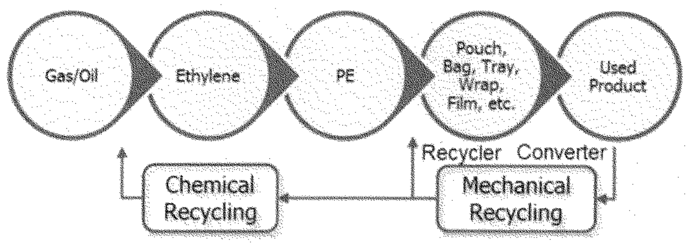
[2] https://plastics.americanchemistry.com/Reports-and-Publications/LCA-of-Plastic-Packaging-Compared-to-Substitutes.pdf

to recycle than other materials because of its low density and wide range of plastics collected (i.e. 1 through 7) which may be incompatible. Innovation is needed to improve the ability of equipment to sort and process hard to recycle materials. Two terms commonly used to describe plastic recycling are mechanical recycling and chemical recycling. The figure below is a simplified illustration of where the chemical and mechanical recycling processes return material back into the value chain.



Mechanical Recycling

Traditional mechanical recycling is an excellent first step in getting value from the used plastics and has significant environmental benefits.[3] Mechanical recycling can be deployed locally and with lower capital than feedstock or chemical recycling. However, mechanical recycling has a significant limitation in the end product performance and is only suitable for a limited number of high volume applications. Mechanical recycling inevitably adds additional heat histories to the polymer chain degrading the material's structure. At the same time, it is extremely difficult to remove all the contaminants (dirt, inks, fiber, adhesive, additives etc.) that are included in the recycled stream all of which impact performance. Dow is supporting innovation in mechanically recycled material through material and application development. We are working to develop large end markets where the performance of mechanically recycled product is adequate and fit for use.

With regard to material science, Dow is working to develop high performance resins, additives and compatabilization technologies to minimize issues like cross-linking, high odor, and off-color that are commonly associated with recycled plastics. Dow's VERSIFY™ copolymers are an example of technology that is used to compatibilize polypropylene and polyethylene. These materials enhance the performance of recycled polyethylene contaminated with polypropylene to allow recycled content incorporation. Another development is Dow RETAIN™ polymer modifiers which compatibilize EVOH and nylon polymers which are commonly used in food packaging for food preservation. Dow's RETAIN™ polymers in EVOH-based packaging, coupled with high-performance polyethylene resins allow for a stand-up pouch to be accepted in the store drop off.

Even with these advances, mechanical recycling of all plastics is a significant challenge because of the wide range of materials introduced into the recycling stream, complex multi-material plastic structures, additive packages, and heat degradation which occurs during processing. Plastic in this state does not work well in traditional mechanical recycling systems. Additionally, it is very difficult to produce mechanically recycled

[3] https://www.oregon.gov/deq/mm/production/Pages/Materials-Attributes.aspx

plastic that is compliant with Food and Drug Administration regulations. These challenges require innovation that can be addressed by feedstock recycling.

Chemical / Feedstock Recycling
Chemical or Feedstock Recycling is an advanced recycling process of depolymerizing a plastic resin back to its individual building blocks where it can then be introduced into the front end of the polymer manufacturing process. This process is very similar to the recycling of paper. When cardboard boxes are recycled, the box is not broken down into a flat piece of cardboard and re-folded to make a new box. Rather, collected boxboard undergoes a pulping process where the board is broken down to its original cellulosic fiber to be made into a new sheet that will be fabricated into a new box. Depolymerization of plastic takes it back to its original molecules that can be reconstructed into new plastic with virgin-like performance capable of being used in the most stringent applications. This process removes impurities and containments like inks, dyes, colorants, fiber, etc. that otherwise impede mechanically recycled polymer performance.

Feedstock recycling is a broad term that refers to a range of approaches to return plastic to virgin or near-virgin quality. Solvolysis, gasification, and pyrolysis are types of feedstock recycling. Nylon and PET are particularly well-suited for the solyvolysis type of advanced recycling. This is a chemical solvent process that breaks the polymer into monomers. Polyolefins, the most widely used plastic, require a thermo-cracking process to break the carbon bonds of the long molecular polymer chains to the fundamental building blocks or monomers. Two technologies used for thermo cracking are pyrolysis and gasification. Pyrolysis heats plastic in the absence of oxygen, breaking it down into a mixed hydrocarbon stream that can be further processed into liquid fuel, liquid petrochemical feedstock or wax.

Gasification also heats plastic, but at higher temperatures converting into synthesis gas (syngas). Gasification can accept a mixture of organic compounds (plastic, biomass, cellulosic, textiles), which expands the range of material accepted and simplifies collection and sortation. The syngas can be further converted into fuel or petrochemical feedstocks. These are both reasonably mature technologies; however, they have not been widely used to create new plastics. Process innovation is required to improve the quality of the syngas, reduce capital intensity and match to the scale required. Equally important are that new business models and value chain partners develop to find solutions for aggregation of discarded plastic to minimize prohibitive logistics costs.

Dow is actively researching the plastic conversion processes of pyrolysis and gasification. We have projects ranging from process technology improvements through to effective conversion to polyolefin plastics.

Collaboration and Partnerships

Dow is committed to advancing a plastic circular economy and is working to multiply the impact of our efforts through numerous global and local collaborations with governments, NGOs, industry, our own employees, and other partners to bring forward solutions.

- Dow and others have partnered on the Materials Recovery for the Future (MRFF) project in Pennsylvania to demonstrate and bring advanced process technology to the sortation process in this step of the value chain.[4] The goal is to demonstrate that more material, flexible packaging in particular, can be collected curbside, and sortation can be improved, ultimately improving the bottom line for the facility while simultaneously collecting and using more recyclable material. Bringing these sorts of innovations to scale is an opportunity to support growth of U.S. recycling infrastructure in a way that will create U.S. jobs and support new industries.

- Dow worked with a local paving partner to construct polymer modified asphalt roads using post-consumer recycled plastic in Lake Jackson, Texas. Additional opportunities for incorporating recycled plastic into asphalt are moving forward in Michigan. This innovation offers a way to maintain or improve the performance benefits of traditional polymer modified asphalt, while lowering overall costs.

- In 2014, Dow and Reynolds Consumer Products, owners of the Hefty brand, initiated the Hefty® EnergyBag® program. Under this program, consumers bag their hard to recycle plastics (those not accepted as part of curbside recycling programs) in a high-visibility orange bag, that is then collected with the rest of their recyclables. The bags are then aggregated at the MRF and shipped to locations where they are converted back into end markets, such as fuel or other building products. This program diverts plastic from landfills and demonstrates that hard to recycle plastics can be collected at curbside and converted into energy, fuels or other feedstocks. The program is successfully operating in 3 U.S. cities (Omaha, Boise and Cobb County, GA) and to date has reached 125,000 households, collected more than 536,000 bags, and diverted 357 metric tons of waste from reaching landfills – the equivalent of 1,700 barrels of diesel.

- Dow is a founding member of the Alliance to End Plastic Waste (AEPW), a newly formed organization committing more than $1.5 billion over the next five years in multiple projects, including on-the-ground waste management and infrastructure development in the geographies needing it most, beginning in the Asia-Pacific region.

- Dow is a founding partner of the World Economic Forum's Global Plastics Action Partnership (GPAP), which is funded and supported by the governments of Canada and the United Kingdom, as well as several companies, to drive a public-private partnership focused on infrastructure development in areas where the rate of plastics waste leakage is the greatest. The first project was kicked off in Indonesia in March 2019, with projects expected in Ghana and Vietnam later this year.

- Dow is working closely with the leading industry organizations in the U.S. – the Sustainable Packaging Coalition and the Association of Plastics Recyclers – to improve and increase recycling through education and awareness programs as well as provide technical guidance and resources.

- Together with several other major global brands, Dow became a founding investor in Circulate Capital's $100 million effort to incubate and finance companies and infrastructure that help waste from reaching the oceans.

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[4] https://www.materialsrecoveryforthefuture.com/

- Dow has announced it will donate $1 million to the Ocean Conservancy over the next two years to support waste collection and recycling solutions in Southeast Asian countries.

Policy Challenges

Increasing recycling rates and expanding the materials collected will not happen on its own, and there are important steps Congress can take to enable growth in this sector.

- *Definitions*: Advanced plastics recycling and recovery facilities that deploy gasification or pyrolysis technology should be universally defined and accepted as recycling. Definitions of recycling should be broad and technology neutral, so as not to prevent the development and deployment of new technologies.

- *Standards*: Increasing the capacity of advanced plastics recycling will require implementation of an industry-wide mass-balance based accounting system to certify plastic recycled content. During the chemical recycling process, plastic resins are depolymerized and fed back into the manufacturing process, at which time it is combined with virgin inputs. At this point there is no molecular difference between the recycled material and virgin material, and impossible to distinguish one from another. In order to make claims regarding or certify compliance with recycled content requirements, industry needs an accounting system in place to track substances through the manufacturing process.

- *Recycling Infrastructure*: Adequate recycling infrastructure – both at the local collection level and in sorting and process – is a major barrier to increasing recycling rates among the public. Dow and the industry welcome the opportunity to partner with Congress on incentivizing investment in new recycling infrastructure at the federal, state, and local levels.

- *New end use markets*: Recycling is enabled by profitable end use markets for the recycled materials. New end use markets also support new manufacturing jobs and increasing the competitiveness of the U.S. economy. Dow is actively working with value chain partners to find new end use markets for recycled plastics, and we welcome support from Congress on additional opportunities to achieve this objective.

Conclusions

Thank you for the opportunity to testify on this important topic. Products made from plastic enable much of our modern society, including food packaging used to keep food safer for longer, lightweight packaging that reduces fuel usage – and associated emissions – in the transportation of several materials, and important medical applications that protect medications and supplies from contamination. However, too many plastics are ending up in the environment or are being lost to landfills. Dow believes plastics are too valuable to be lost in such ways, and we are committed to working with governments, NGOs, communities, and value chain partners to advance the plastic circular economy.

We believe chemical recycling is critical to increasing recycling rates and sustainable material management in a circular economy. Chemical recycling does not face the same challenges as traditional mechanical recycling, including contamination, compliance and performance. However, chemical recycling presents a new series of challenges that must be overcome, including scale and cost. We need a comprehensive understanding of the lifecycle impacts to ensure we are implementing the principals of a circular economy in a sustainable way. Chemical recycling can have a significant impact in addressing global plastic waste and needs to be developed in concert with mechanical recycling to deliver a holistic set of solutions for society.

We look forward to working with members of the subcommittee and all interested stakeholders on these important issues.

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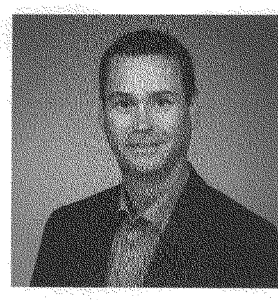

Tim Boven
Recycling Commercial Director
Packaging & Specialty Plastics

Tim Boven is currently the Recycling Commercial Director for the Americas within Packaging and Specialty Plastics. He is responsible for developing new business models and growth strategies that monetize hard to recycle plastic streams across the Americas. This includes evaluating plastic waste streams, new applications to drive demand, technologies to enhance mechanical recycling, and chemical recycling technologies that will advance a circular plastic economy.

Boven joined Dow in 1997 on the research assignment program where moved into Emulsion Polymers Research focusing on process development. In 2000, he joined Dow Automotive where he held numerous roles in Technical Service & Development, Application Development, Sales, Marketing, and Product Management. In his last role, he served as the Dow Automotive Global Business Director. In April 2014, Boven joined Dow Hydrocarbons as the C4 and Comonomers Business director. He added Business Supply Chain in June 2015 where he was accountable for Business Supply Chain, C4 business profitability, and comonomer asset optimization / sourcing strategies.

He holds a BS in engineering from Western Michigan University and an MBA from Central Michigan University.

Chairwoman STEVENS. Thank you so much.

At this point we are going to begin our first round of questions, and the Chair is going to recognize herself for 5 minutes.

Undoubtedly, where we see challenge and identify challenge as a Nation, we readily want to turn that challenge into opportunity, and that is something that I heard from all of you in your scope of work and in your testimony.

Mr. Sincock, I'd like to just drill down for a minute with you. Since these new changes from China have been implemented, could you just explain a little bit about what our small town of Plymouth, the city of Plymouth, has been experiencing with its recycling?

Mr. SINCOCK. Certainly, the city of Plymouth, we have been—we're right toward the end of our contract with our solid waste and recycling hauler, so we've been OK at this point, but several of our neighboring communities, you know, we all talk, and are feeling the pinch and, you know, we have also had our contractor come to us and say, look, recycling costs are going up. We need more help. We need you to take a look at, you know, perhaps amending our contract, those kinds of issues.

So we're seeing that there's more issues with the recycling, especially plastics, in trying to make sure that our residents are able to still have a program that is viable from a—you know, an operational standpoint, you know, that's not cost-prohibitive. And that's really where the—tends to be the trend is going at this point, is significant cost increases from our haulers and recyclers related to the product, and that obviously passes down to our residents.

Chairwoman STEVENS. And as you have spent time educating the public on the benefits of recycling or encouraging them to recycle, what challenges have you run into? What things have you seen that worked best in terms of recycling campaigns? And have you started to hear about this fear of cost?

Mr. SINCOCK. Well, certainly one of the things—the big challenges that we have is do we back our recycling programs down? You know, we've spent so much time and effort building up the recycling programs, you know, our community has very high and impressive rates of recycling in Wayne County, but it also becomes an issue for our residents if we are going to back down from the really good programs that we currently have and the amount of education that we put into it. And it's a hard sell at the municipal level that—I call it the reach-out-and-touch-me level of government where, what do you mean, we're not recycling whatever the product may be? That's a hard, difficult conversation to have with our residents.

Chairwoman STEVENS. Do you see a revenue opportunity for the city in recycling or, you know, continuing to build out your programs? And are there ways that the Federal Government can help you to meet those goals?

Mr. SINCOCK. Well, I think what the issue is on the revenue side is—and it depends on the municipality. Our particular contract, we wanted to stay out of the swings in the market, so in our particular case the vendor takes all of the risk as to market upside and market downside, so we're not affected. Our price stays constant. Now, we don't get the benefit of, you know, when recycling, you know, markets go up and the contractor gets to receive some benefits there, but on the flipside of that, we don't have to deal with the downside.

And so that's—you know, other municipalities get—they split the value of the recycles between the vendor and the community. The community will get a small percentage of the recyclables. But as the market goes down, that percentage goes down to near zero or less than zero.

Chairwoman STEVENS. We have our storied traditions and best practices in Michigan with our recycling programs and our buyback programs. I think it's evident that there are certainly opportunities and revenue opportunities, as well as sincere environmental considerations for us to meet, and yet the onus is on our consumers and it's on our taxpayers, and it's sort of reliant on the altruism of our residents to recycle and to not throw—I commend all of you who talked about the greasy pizza box in your testimony because—at least two of you did. But in terms of how we're stymied or how we can meet some of our bigger goals and some economic opportunities. You know, I commend our last two witnesses for mentioning the circular economy and what that means for us and how in sync we really are.

I'm out of time, so I'm just going to conclude with one of the results that we want to take from this hearing is identifying Federal opportunity to partner with you in your respective fields and portfolios of work to lead to increased recycling, meeting environmental goals, as well as economic opportunity based on technological advancement.

And, with that, I'm going to recognize my colleague, Mr. Baird, for 5 minutes.

Mr. BAIRD. Thank you, Madam Chair.

Mr. Boven, the Subaru plant in Lafayette, Indiana, which is in my district, has been a zero-landfill facility since 2004, and that reflects a commitment by the company to have as little environmental impact as possible. Can you elaborate for me what Dow and the plastics industry in general has been doing to work with the front-end sustainability idea and not just the back-end sustainability in producing products?

Mr. BOVEN. Yes, sure, thank you, Congressman. So at Dow I can speak specifically. We've had a series of 10-year sustainability goals. Now, we're in our third generation of those. They go out through 2025. And the sustainability goals that we have at our company are really around defining blueprints for designing sustainability into the future. So when you talk about plastic circularity in particular, the big initiative that we're very involved with is designed for recyclability. How do we help our customers, how do we help the marketplace design products that can be recycled in the end?

Today, a lot of packaging, as an example, has gone to very complex structures, which create problems for the recycling industry. And so what we're working with them on is all polyethylene-type structures, as an example. And the reason we're doing that is because polyethylene is one of the largest-collected plastics today, so if we can get more materials into common materials that can be collected, that can help with increasing plastic recovery and plastic recycling.

This is one example. We have a lot of initiatives of materials science in terms of increasing resins that can incorporate recycled content, as well as end market. We're working on new market applications so we can create new large-volume applications to create these markets that people say don't exist. This is where we're spending a lot of our time.

Mr. BAIRD. Thank you. And continuing on in that same vein, in your testimony you discussed the benefits of chemical recycling. What's needed to scale up and bring down the cost of chemical recycling and make it more viable in the United States? Anything?

Mr. BOVEN. That's a very good question. One of the things that we're looking at aggressively is, how do we address that very topic of scale? When you look at the petrochemical industry today, it's been capitalized around very large fossil fuel deposits. When you talk about using plastic as a feedstock, plastic is everywhere. So a significant challenge that we are working through and trying to address with value chain partners is how do we aggregate plastic and bring it to a central location so we can get the appropriate amount of feedstock to build the appropriate scale we need to be meaningfully effective?

At the same time, we're working on the capital intensity equation to try to bring down the capital intensity per metric ton of product produced so we can put feedstock recycling located where the feedstock is, in this case, waste plastic.

Mr. BAIRD. Thank you. Another question—have I got time I think? Dow and the other companies are investing heavily in new sustainable material and in recycling technologies. What's the market incentive for industry to invest in research in that area?

Mr. BOVEN. Well, quite frankly, society is demanding it. The plastic waste issue, you can't turn on the television, you can't go to the internet without seeing it. And society wants solutions to this. So we look at this as, yes, it's a big challenge, but it can be an opportunity for those who want to make those investments today and work toward addressing the problem of the future. So this is how we see it. It's going to be absolute, and it's where we're putting a lot of time and effort.

Mr. BAIRD. Thank you. And one last question if you will.

Mr. BOVEN. Sure.

Mr. BAIRD. How would developing standards for plastic materials and recycling help advance the industry in the United States and maintain America's leadership in that field?

Mr. BOVEN. Standards in what regard?

Mr. BAIRD. I was thinking about any of the things that relate to regulation of plastics or the quality of the plastics.

Mr. BOVEN. Thank you. So one thing that will help certainly is to create definitions around what recycling is. Today, when we look at what people want and require, it's high-end recycled material. That's not going to be possible without advanced recycling technologies. Today, there is no universal definition of recycling. And as we look to bring forward new technologies, we want to make sure that technologies like pyrolysis, gasification, solvolysis, those types of processes are included in the definition of recycling. And this would be increasingly important as people look to put policy around. We know there are States that are having these discussions, and if they start putting policy around recycling targets, definitions will follow. And we want to ensure that there's broad definitions that don't preclude technology.

Mr. BAIRD. Thank you very much. And I yield back my time.

Chairwoman STEVENS. The Chair now recognizes Mr. McAdams for 5 minutes.

Mr. MCADAMS. Thank you, Madam Chair, for convening this timely and important hearing.

And thank you, Mr. Sincock, Dr. Menon, Dr. Beckham, and Mr. Boven, for your testimony here today.

In my previous role, I was the Mayor of Salt Lake County, and I worked to enhance our waste management practices to achieve our environmental goals, and it often aligned with our fiscal objectives. We found that they were oftentimes the same thing. Whether collecting green waste to break down and resell or capturing methane leakage for energy generation or landfill, technologies made our waste management greener, smarter, and less costly to taxpayers.

So I'm excited today to have the opportunity to discuss how we can make use of new and forthcoming technologies to make our plastics sorting, management, and recycling more effective and profitable in recycle and upcycle applications. We've also seen some of the challenges as global interests in some—in some of our recycling has waned, and so—my first question is for you, Mr. Sincock.

As boots on the ground in your town, what's been the most effective tool that you've used to help residents to improve their recycling practices, the individual practices?

Mr. SINCOCK. Education, and it's ongoing and multifaceted. So it's mailers to the home, it's stickers on the trash carts, it's social media. All of those things are a critical element to ensuring that the plastics industry has a quality product to deal with.

Mr. MCADAMS. And what's the most common request or complaint that your community voices about your recycling program or what have you done to remedy any concerns that were raised?

Mr. SINCOCK. The most common complaint is that we don't recycle enough——

Mr. MCADAMS. Yes.

Mr. SINCOCK [continuing]. And that—you know, it becomes a challenge as to how do we have a product that somebody else is going to use.

Mr. MCADAMS. So, Dr. Beckham, in your testimony you said that recycling alone can save 40 to 90 percent of the inherent energy in plastics relative to the production of new plastics. Does this apply to both chemical and mechanical recycling?

Dr. BECKHAM. Most of those statistics were currently obtained in the context of standard today's mechanical recycling.

Mr. MCADAMS. Do we have good estimates for potential energy savings using chemical recycling?

Dr. BECKHAM. Right. I think judicious lifecycle assessments, techno-economic analysis, as well as, just generally supply chain energy analyses are forthcoming, but we have looked at PET upcycling, for example, using chemistry to produce two composite materials, and they have shown over standard composites manufacturing can save up to 60 percent of the supply chain energy and reduce greenhouse gas emissions quite considerably as well.

Mr. MCADAMS. It's promising. Dr. Menon, what technologies could help us—could help simply—to simple—simplify decision-making for Americans as they sort their waste into trash or bin recycling every day? And maybe that's generally as a question, but I've also—there have been some experimental technologies that I've heard about or haven't had the opportunity to actually witness them but—about single streaming both waste and recycling, and your thoughts on that.

Dr. MENON. In terms of technology, the real issue is access to technology. It's one thing for academia to have instrumentation. It's another thing entirely for recycling facilities to have instrumentation. So perhaps one of the things that we should look into particularly from the point of view of academia is to make technology affordable. Can we reinvent instrumentation that is more affordable and more accessible? Recycling companies make pennies to a pound, so every dollar, every pound of recycling material matters. So they're not able to invest necessarily into technology, so maybe a new generation of affordable technologies is what we're thinking of at this point rather than reinventing technology as well. But, as was mentioned by Dr. Beckham, of course chemical recycling is—it's virgin territory in terms of large-scale recycling, so that is something we would be considering as well.

Mr. MCADAMS. So I guess my question to all of you, and I'm about out of time, but what infrastructure are we lacking as a country? What—and what can we do to—as a Congress to further incentivize these investments in R&D and then deployment of technology?

Mr. SINCOCK. Well, I think the issue for us at the local municipal level is where's the end product, and is there a use, and then how do we cost-effectively collect that material? And, you know, mixing it into a single stream is interesting.

Mr. MCADAMS. I've seen the technology. As a Mayor, it was troubling to me because I was—the technology is there. My concern was is it viable and in experimenting with that, do we lose all the ground we've gained with educating our consumers on sorting going single stream, then have it fail and we just lost.

Mr. SINCOCK. Exactly.

Mr. MCADAMS. Yes. Thank you. I yield back.

Chairwoman STEVENS. The Chair now recognizes Mr. Balderson for 5 minutes.

Mr. BALDERSON. Thank you, Chairwoman.

Thank you all for being here this afternoon.

This question goes to Dr. Menon and Mr. Boven. I had a question for all of you, but the gentlemen down there took my question, so, currently, municipalities set their own recycling standards depending upon what the facility in the area is capable of processing. They can vary widely from city to city depending upon the local infrastructure.

Dr. Menon, you've touched on NIST's efforts to create processing standards in this space. Recently, the university, as you stated, received a grant to work on expanding this. While I understand the draw toward this, I remain concerned that the Federal Government is not best suited to achieve this goal. Ensuring that recycling plants across the country have the same processing abilities, however, would lessen the amount of plastic that needs to be exported for processing. Could you speak about what you have found in your research on this subject?

Dr. MENON. Thank you very much for the question. I do believe NIST is the right agency. In particular, we don't have a universal standard when it comes to recycling plastics. If you look at the resin identification code, the numbers 1 through 7, it tells you the polymer content in a bottle. It doesn't tell you anything about the contaminants, nor does it tell you how to recycle the product. So setting these standards is a gamechanger when it comes to recycling, and setting standards is what NIST does. Thank you.

Mr. BALDERSON. Thank you. Mr. Boven, are the suggestions that Dr. Menon offered something that Dow could see working in the marketplace?

Mr. BOVEN. Yes, thank you for the question. Yes, the answer is yes. In fact, there's—this is—the Sustainable Packaging Coalition where that group has already developed and working toward developing recycling standards for packagers to put on their labels, both paper and plastic, the how-to recycle label. And it gives implicit instructions to consumers on the packages they buy on how to recycle it, whether it be not recyclable or store drop-off. Those types of instructions are put on it. That's a first step, and that is working at cleaning up the recycling streams today because one of the issues is you have wish cyclers who put everything in their single-bin collection system, which actually creates a lot of problems for the MRFs and you have a lot of rejected material because of that, so it starts with cleaning up what goes into the recycling bins first.

Mr. BALDERSON. OK. Thank you very much. I yield back my remaining time, Madam Chair.

Chairwoman STEVENS. Yes. The Chair would now like to recognize Mr. Foster for 5 minutes.

Mr. FOSTER. Well, thank you, Madam Chair, and thank you to our witnesses.

Let's see. Most of the talk so far has been on thermoplastics, PET and polyethylene. Are thermosets and cross-linked plastics pretty much a lost cause for recycling or are there enzymatic systems that may depolymerize them and allow them to be recycled?

Dr. BECKHAM. So I'll take that. So thermosets today are indeed very challenging to recycle because it's hard to get them to flow in the context of the mechanical and thermal recycling paradigms we have now. Thinking forward to recyclability by design, there is an emerging field in polymer science around this concept of vitrimers where you have cross-links that are able to be chemically broken down, so you would imagine taking a thermoset, a composite material, dumping it in, for example, to acid, and breaking that down into flowable polymers again. There's an enormous opportunity here for recycling.

A wind turbine blade, which is a cross-linked thermoset, which we can't do right now, we grind it up and put most of it into the landfill or burn it. But I think emerging chemistries for recyclability by design for composite materials that would go into a wind turbine or car or snowboard or whatever have enormous potential, so——

Mr. FOSTER. And do structural fibers that are, you know, carbon fibers or other fibers put in, do those make life really rough for recycling as well?

Dr. BECKHAM. Certainly, traditional polyacrylonitrile carbon fiber today is very challenging from a recyclability perspective. Again mostly, it's thermal energy recovery is sort of the place that's routed to. There are emerging chemistries from the academic community and generally the U.S. research community on ways to break down polyacrylonitrile-based carbon fiber, but that's incredibly challenging. So, again, I think we need to rethink how we're putting those carbon fibers together and think about recyclability by design, as well as lifetime performance——

Mr. FOSTER. And so by the thermal—you mean that is pyrolysis and gasification, what you're saying——

Dr. BECKHAM. As well as just simply burning it for energy recovery in some cases.

Mr. FOSTER. OK. And actually, Mr. Boven, you mentioned in addition to pyrolysis and gasification something that sounded like solvolysis or something. What was—that's not something I'm familiar with.

Mr. BOVEN. Yes, solvolysis. So solvolysis is a solvent-based process. It's commonly used for PET and nylon. Those polymer architectures are well-suited for that where you can use a solvent to break it down into monomer and then you can build it back up.

Mr. FOSTER. OK. All right. So it's a solvent. Got it. I understand. I think I used to do that with Styrofoam and model airplane glue as a child. Now, see, look at that, there's a lot of common experience in that, the first time you tried to do that and it didn't end well.

So what fraction then of the current plastic production stream are easy targets like PET and high-density polyethylene? Is that 80 percent of the plastics production that are things we ought to be able to recycle or are there just a million small streams that will all each have to be dealt with?

Mr. BOVEN. Well, polyolefins are—polyolefins being generically polypropylene, polyethylene, are the largest polymer family used in packaging-type applications, non-durable applications, applications that have a life that's less than, say, a year. And those are the targeted—where we should put a lot of effort in recycling and recovery, and they have large end markets as well. So if you can recover those materials, you have the opportunity to recycle those and find homes for them.

Mr. FOSTER. But is that 50 percent of plastic production or just another 20-percent hunk?

Mr. BOVEN. No, it—I'd have to get back with you, sir, on that exact question, but those two polymer families are the largest. It's directionally just south of 50 percent are polyethylene-type materials.

Mr. FOSTER. OK. And, now, according to Wikipedia, if you look at polyethylene terephthalate, a majority goes into fibers. And so is it—how do recycle fibers if someone makes, you know, a Dacron shirt or something like this? Are you really going to recycle that?

The number in Wikipedia was about 50 percent going into fibers, and is that a whole separate struggle to even collect it in a pure stream?

Mr. BOVEN. The challenge there is collection of textiles, yes. You have to collect it, and then you would have to put it in some sort of chemical recycling process to effectively recycle it.

Mr. FOSTER. Right. And these are often mixed with cotton and so on, and so it's a difficult—are there any plausible ways to make that happen, to recycle clothes that are made with multiple fibers?

Mr. BOVEN. So chemical recycling, feedstock recycling has the opportunity, depending on the technology route that you take. Gasification, as an example, is a technology route that can take any organic material, so it can be biomass, it can be fiber, it can be plastic. You can put it in there. That will break it down to fundamental syngas, and from syngas, we can do lots of different things with it.

Dr. BECKHAM. If I can just add one thing in terms of PET mixed with cotton, which is a lot of polyester clothing, enzymatic processes are exquisitely selective to go in and break both the Ester bonds in PET, as well as the ether bonds in cellulose or cotton to make sugars and mixtures of these building blocks of PET. So I think there's a lot of potential there as well.

Mr. FOSTER. OK. Thank you, and I yield back.

Chairwoman STEVENS. The Chair now recognizes Mr. Gonzalez for 5 minutes.

Mr. GONZALEZ. Thank you, Madam Chair. Thank you, witnesses, for being here today.

I first want to use this time to recognize the University of Akron's College of Polymer Science and Polymer Engineering, which is recognized as being one of the world's best in the polymer sciences. The University also does great work getting young students excited about the polymer sciences through their Akron Global Polymer Academy, which provides opportunities for teachers and students of all ages to experience the world of polymers by organizing in-school visits and field trips to the university's research facilities. They're doing a fantastic job. Polymer research and development has been huge in northeast Ohio, where I'm from, for my entire life and before it, so we're proud of that.

I want to take my time to really just understand this a little bit better frankly. And my first question will be to Mr. Boven. I'll probably stay with you if that's OK. I first want to understand the interplay between mechanical and chemical in the context of the circular economy. It strikes me, as I read your testimony, that chemical is probably how we get there ultimately. I'm sure there's obviously a role for mechanical, but can you just kind of walk me through that for a second?

Mr. BOVEN. Yes, sure, thank you for the question. So when you look at the—there is a relationship between mechanical and chemical recycling in the sense that we would suggest that, if it can be mechanically recycled, it should be. It should be because there's a lower carbon footprint. It's not as energy-intensive, and it can be deployed locally, right? You can do mechanical recycling at a very local level very effectively. The challenge with mechanical recycling has always been finding end markets——

Mr. GONZALEZ. Right.

Mr. BOVEN [continuing]. Because you'll have some polymer degradation. Products that cannot be introduced into mechanical recycling system effectively are the products that should go into chemical recycling because at that route you can address the contamination issues that come. And in fact, when you talk about MRFs today, on average, about 25 to 30 percent of the material going into a MRF is actually rejected because it's too——

Mr. GONZALEZ. OK.

Mr. BOVEN [continuing]. Highly contaminated to be processed. You can feed that into a chemical recycling process to then recycle the product.

Mr. GONZALEZ. Thank you. And then my second question, when it comes to chemical recycling, and I'll score these 1, 5, and 10, so if 1 is sort of we understand what needs to happen but we haven't really started developing, 5 is our tech is viable but we need to find business models to get it deployed more in the market, and then 10 is we understand the tech, we understand the business model, we just need to deploy and scale, where are we on chemical manufacturing?

Mr. BOVEN. I would put us at a 5——

Mr. GONZALEZ. OK.

Mr. BOVEN [continuing]. Quite frankly.

Mr. GONZALEZ. OK.

Mr. BOVEN. When we're talking about chemical manufacturing, we're talking about mature technologies like gasification, pyrolysis. They've been around for a long time. They have not been used widely for the purpose of recycling plastic, and so we're talking about putting a value chain together and different partners together to aggregate the plastic to get it to a chemical recycling facility. From there, you turn it into an intermediate, and then you have to integrate it into the current petrochemical industry.

Mr. GONZALEZ. OK.

Mr. BOVEN. So we have to work on the business model side.

Mr. GONZALEZ. OK. So it's a combination of business model. Once we get there, then we can scale it.

My last one—and I kind of hate to go here, but these paper straws, they are my pet peeve. I took my son the other day to get a milkshake. He's 1-year-old. We do this on Saturdays, paper straw shows up, the thing disintegrates before we're a third of the way through. He's also throwing whipped cream at my face, so, you know, all kinds of things going on there.

I personally despise them. On top of that, only .025 percent of plastic that's flowing into the ocean is straws, plastic straws. They also require more energy to manufacture than plastics. So I kind of want to just have you give me some hope that maybe Dow is working on either new technologies, new bioplastics that are more efficient and better for the environment or that we're making progress on the sort-ability because my understanding is the reason why it's hard to recycle plastic straws is because it's hard to sort them. So give me some hope, please.

Mr. BOVEN. Yes, we should take hope. There is hope, and I say that because plastic pollution is now widely accepted across the world. And you see collaboration happening across the value chain that hasn't happened at least in my 22 years in the plastic industry. You see industry partners coming together making investments like the Alliance to End Plastic Waste, where over $1 billion has been committed to fund solutions to drive the ending of plastic waste. Now, is $1 billion enough? I know $1 billion is a great start, and we expect it to continue to grow.

When you talk about biodegradability or bio-based plastics, those are two very different things. We think the focus needs to be on investing in infrastructure to recover the plastic and retain its value. That's where we're spending a majority of our time, and we don't want to get distracted with other things that aren't going to have a meaningful impact.

Mr. GONZALEZ. OK. Thank you. And I yield back.

Chairwoman STEVENS. It looks like we'll be calling the T&I Committee after this hearing based on those repeated claims.

The Chair is now going to recognize Mr. Cohen for 5 minutes.

Mr. COHEN. Thank you. Good news for your son, a gift you can get him and I would get him if—and should get him and present to you, you can buy steel straws, and he'll have his own straw to get his milkshake out of, and it'll be real cold when it comes up, which is a nice feeling. Plastic does not give you that nice feeling, but a cold steel straw is a very attractive thing. On the internet you can get them—a set of 20 for $9.99, wholesale, Amazon.com.

Mr. GONZALEZ. Mr. Cohen, his birthday was 2 weeks ago.

Mr. COHEN. Oh, wow.

Mr. GONZALEZ. We accept. We accept.

Mr. COHEN. Would he still accept gifts?

Mr. GONZALEZ. Oh, absolutely.

Mr. COHEN. Good. Well, I will get him one.

Mr. GONZALEZ. Thank you.

Mr. COHEN. A set. I've got a friend in Los Angeles who's big in the Anti-Plastics Coalition, Dianna Cohen, no relation, and she's given me steel straws. And I don't use straws that much, but when I do, I find a great sense of tactile, you know, pleasure out of using that steel straw, which I never got out of a plastic straw or certainly not a paper straw. So this is a whole new day for everybody really.

Now, I would like to ask Mr.—is it Boven? Last year, I had a bill which passed the House that said we would not use plastic straws in the cafeterias, and it passed, but it passed over the objections of Dow Chemical I think. There was a Congressman from—that worked for Dow, represented Dow, et cetera, got a lot of money from Dow, and he worked against it and got—wanted to get—water it down. Why can't Dow come up with something that is good for the environment rather than things that are bad for the environment and work against us making the environment better?

Mr. BOVEN. Congressman, thank you for your question.

Mr. COHEN. I'm sure thank you is not what you really meant, but thank you for saying that.

Mr. BOVEN. I'm not an expert in the policy side or familiar with the discussion that you're talking about, but we can have our D.C. office get back to and address that question.

Mr. COHEN. Well, that'd be all right I guess, but, you know, we—I think we're changing our policies, and we ought to be—like right now, there's a whole bunch of plastic bottles with water out there.

We really shouldn't be using plastic bottles with water, and I brought it in and all of a sudden I thought, what are we doing? I mean, we've got these cups here, this is great, but we ought to be carrying around our own and pouring water into them from the sink. Potomac water is fine.

Mr. SHERMAN. I second that motion.

Mr. COHEN. And—exactly. Good work, Brad. And not using plastic as much as we can. It's reduce, recycle, and reuse. Well, reduce, and that's what you—we've got to do because it is getting in the water and animals are dying. The—you know, they found whales with tons of plastic in their gut, and they think it related to their deaths. And there's all kind of sea life that is being killed because of plastic pollutions in the oceans. So we need to stop using plastic as much as we can.

Dr. Menon, do you have any ideas on how we can maybe create or use paper, something else, anything other than plastic? And I know this is made of plastic, but this is reused.

Dr. MENON. Mr. Cohen, thank you very much for the question. I do not often know of a material that would replace plastic so easily. It exists because of the availability, the ease, and the versatility. So it is not easily replaced. But maybe there are plant fiber solutions that we could think of that would be easier to at least degrade easily.

But I would like to make a comment regarding one of the statements you made. So in the Mariana Trench, which is deeper than Everest is tall, every animal species found had plastic in their guts, so this is where we are when it comes to plastics recycling. And plastics recycling in the ocean, that's an entirely—I mean, so that's an impossible task. It shouldn't get there in the first place.

Mr. COHEN. Yes, well, we need to find a way to reuse or reduce our use of plastics and then reuse whatever possible. And recycling is great and I recycle everything I can, and I hope Memphis does a good job on it, but, you know, it's just a different—today, I went—and I'm very proud of what I did today because I've been obsessing on it. These glasses, eyeglasses, I like them a lot, and I've had them for long time. And I got them to replace a pair of sunglasses I had that I really loved. They were American Optical Saratogas, which were the same glasses that John Kennedy wore, sunglasses. And so John Kennedy wore them, I wore them. You know, he was in the House, I'm in the House. That's as far as it goes.

And my sunglasses—I broke them about 15 years ago I think, and then I broke these about 3 weeks or a month ago. Everybody in the world tells you, you can't repair plastic, it's impossible, it's done. Well, I'd saved those glasses from 15 years ago, and these, and I took them to a guy up here at 750 17th, and he fixed both pair of glasses. You can't see the—that they were broken, and these were broken in two different places, $70, they're back together. Reuse your plastic frames. Don't buy new ones. Get them redone, 750 17th Avenue, right opposite the Executive Office Building, great deal.

And with that, I want to say I love The Graduate, but plastics, no.

Chairwoman STEVENS. All right. The Chair is now going to recognize Mr. Sherman for 5 minutes.

Mr. SHERMAN. Thank you, and thank you for holding these hearings and bringing them to my particular attention.

The gentleman from Tennessee focuses us not only on reduce, reuse, and recycle, but also repair, so the fourth R, but once you get through all four R's, there's a reason why we prefer, from an environmental standpoint, paper straws to plastic straws, and that is that paper is biodegradable. How close are we to developing plastic products that have the advantages of plastic, pretty much the cost of plastic, but are in fact biodegradable? Mr. Boven? You guys anywhere close to that?

Mr. BOVEN. Biodegradable—biodegradable plastics do exist today. PLAs (polylactic acid or polylactides) are an example. Biodegradable plastics present serious challenges to today's recycling infrastructure. They are not accepted into the infrastructure——

Mr. SHERMAN. But they will—you know, a paper straw can't be recycled or I guess is often not recycled, but at least it biodegrades. How biodegradable? How long do you put it in the ground before it disappears?

Mr. BOVEN. Well, Dow isn't producing those resins, but there are biodegradable plastics available. Again, from our perspective, when you look at biodegradability, biodegradability is not going to solve the plastic pollution issue that we have. We want to focus—we don't want to distract from——

Mr. SHERMAN. Well, why is that? Right now, we're recycling 9 percent, so it's 91 percent irrelevant whether it's a recyclable or nonrecyclable plastic; it's not going to be recycled. What is—what tax incentives or whatever could we give for biodegradable plastics? Does anybody have any proposal? Let me move on. We've got these islands of plastic in the—floating in the ocean, mostly plastic. There—is there any commercial value to that which you've subsidized could be used to be chemically recycled? Does anybody have an answer? None of our—yes?

Dr. MENON. So harvesting the plastic from the ocean would be the problem.

Mr. SHERMAN. Right, that's what I'm——

Dr. MENON. So——

Mr. SHERMAN. I mean, it's floating there——

Dr. MENON. Right. So these plastics are——

Mr. SHERMAN. But someone picking it up wouldn't be that—if we picked it up, what would—would we do anything useful with it?

Dr. MENON. Yes, I think most of them are PET in there.

Dr. BECKHAM. Yes, I mean, certainly, if you are able—if you are able to harvest it in an economically viable manner, it would probably be like the same plastics we get at materials recovery facilities already.

Mr. SHERMAN. OK. So these pose a major threat to the environment and the oceans, with the proper incentives, somebody would pick them up, get some subsidy, and use those chemicals for something useful?

Dr. BECKHAM. Potentially, but I think that the engineering challenges of going and harvesting plastics from the ocean are incredible and would certainly need a lot of investment to be able to do that at a scale that would actually make a difference.

Mr. SHERMAN. OK. We have 8.3 billion metric tons of plastics produced globally, 6.3 billion becomes plastic waste, 9 percent is being recycled. The U.S. only recycles 9 percent, China does 25, Europe does 30, so our 9 looks pretty weak. And then you realize some of our 9 is really in Chinese landfills. What can the U.S. do to promote recycling internationally? Does anybody have an answer? Do you want to comment? I'm looking at four witnesses, all of whom are extremely shy.

Dr. BECKHAM. I mean, I would say that——

Mr. SHERMAN. Yes.

Dr. BECKHAM [continuing]. Again, I think the United States has the opportunity to lead the way from a technology development perspective to create chemical recycling technologies that will incentivize the reclamation of waste plastics. If we can do that in the United States, likely those technologies would be deployable outside the United States as well if they—if the economic incentive is there.

Mr. SHERMAN. Is there any particular technology that you think the U.S. Government should be—you know, it's just on the cusp of doing something important but needs some research dollars or incentives. Is there any one area of research any of you would recommend? Yes, Mr. Boven?

Mr. BOVEN. Yes, so research in creating new end applications would be very valuable. One of the problems that's been articulated is that there's not enough end markets for recycling, and so accelerating end market generation would create a home for recycled plastic.

Mr. SHERMAN. My time is expired. Thank you.

Chairwoman STEVENS. The Chair would like to reclaim 5 additional minutes for questions. This is what all of the Committee looks like, by the way, on the Subcommittee for Research and Technology.

I wanted to kind of glom onto something, Dr. Beckham, that you had included in your written testimony where you wrote, "Given the amount of plastics in the food chain, plastics are commonly now found in the human body with potential toxicological effects that are not yet fully understood." And that sentence jumped out at me in a very stark way in part because I view all of you as the solution delivery vehicles of what we want to do on plastic recycling. You're on the solution end, you're on the problem-solving end.

You know, we've heard a few comments. It's been couched within your testimony about some of the illegal dumping that's going on, some of the mismanagement, the missed opportunities to reuse, reduce, and recycle. But I was just wondering if you could kind of help me understand how we could understand these toxicological effects given that you are testifying before a House panel today.

Dr. BECKHAM. I will note that I'm not a toxicologist, but with that caveat, I think certainly there are—there is a large research community that does toxicology and thinking about—there was—for example, there was a paper published a couple weeks ago where they measured micro and sort of nano plastics in the air and found even in pristine environments that you can breathe this stuff in.

How that affects the human body, how that affects animal life in general I think is still very poorly understood. And from my perspective I think that Federal research dollars could be put into the toxicology community to understand those types of things because we don't know. We simply don't know what the effects of those will be.

Chairwoman STEVENS. We find ourselves with a plastic paradox. OK. I wanted to capture that for the record.

And at this time I would like to excuse my distinguished colleague, Ranking Member Jim Baird, who has an appointment to make. Obviously, this has been a robust hearing, and we've heard many rounds. I'm going to yield back the remainder of my time. That concludes—oh, Mr. Sherman has another one? Do you want to go again, Brad?

Mr. SHERMAN. I was just going to ask one.

Chairwoman STEVENS. You can go again. Go ahead. I'm going to cede 5 more minutes to my distinguished colleague, Mr. Brad Sherman, who I am so glad joined us today, by the way. This is the full Research and Tech Subcommittee in action. Thank you. Go ahead, Brad.

Mr. SHERMAN. It's been over 40 years since the last Federal law to promote national research and development program for improving methods of collection and recycling of solid waste. The law was a national effort to recover valuable petroleum-based resources that were filling our landfills. It sounds like a lot of what we're facing today except that the purport volumes are exponentially larger, and the types of plastics are different. We need to find the right balance between the Federal Government having a mandate and States and localities doing it their own way. What do you gentlemen feel is the Federal role here both in research and in mandating procedures at the State and local level? I'll go straight down, Mr. Sincock.

Mr. SINCOCK. Well, I think you bring out a very valid point. Just in looking at our own statistics for the city of Plymouth, we've seen our materials that we've landfilled from 1992 go up from 1,648 tons to—in 2018 to 2,400 tons, but our recycling has also gone up a little bit during that period of time. So I think government—if the government is going to be involved in things, there has to be a national standard of what's acceptable. And I think from that—and industry can move forward from there at least on the collection standpoint.

I agree with you on your plastic bottle there that you bring with you. In our case we've got about 30 employees in our city hall. One of our employees had the suggestion that we replace the drinking fountain with one where you could fill up your bottle. In just over a year, we filled up over 6,000 bottles.

Dr. MENON. Mr. Sherman, thank you very much for that question. The Earth is our home, and charity begins at home. Not every industry is profitable from the get-go. Sometimes governments have to intervene and help start industry. This in particular may be true when you're talking about ocean plastics. It may not be profitable. There's no way to foresee how technology changes and see how if things will be done differently in the future. But as of now, if we have to clean up the oceans, we have to pay the price.

It is where we live. So the burden falls on us, on all of us to help industry in cleaning up the planet. Thank you.

Dr. BECKHAM. So I will echo those sentiments very strongly. I think that one of the roles of the Federal Government is to support research that will allow for revolutionary changes and step changes in the way that we deal with today's plastics, as well as redesign for tomorrow's plastics. And that kind of fundamental research I think will be really critical for, again, enabling a new industry in the United States using chemical recycling.

Mr. BOVEN. Yes, thank you for the question. I would answer your question echoing my comments earlier about definitions. The Federal Government can help with definitions around what recycling is. This will be important as, again, advanced recycling technology is brought to the forefront.

Two, I would say recycling certification, meaning that the advanced recycling systems that we're talking about depolymerizing the product, putting it back into the front end of the polymer manufacturing process, we want to be able to certify what was recycled and then give those certifications to our customer and so they can feel confident that they're purchasing recycled material, much like, say, wind energy as an example.

And last, I would say the Federal Government can help in piloting programs. There's a lot of work being done at looking at new, again, end-market applications for recycled plastic, and so the government can help with piloting these programs to bring them to scale. Dow, as an example, is doing work with using recycled materials in roads and other durable applications like that.

Mr. SHERMAN. I yield back.

Chairwoman STEVENS. Before we bring this hearing to a close, we obviously want to thank our distinguished witnesses again for testifying before us on the Committee today. I think you answered the tough questions as best as you could. You gave us some things to think about. I believe that we're going to meet the charge of this time. I believe that there is a rallying call.

I represent a district in Michigan surrounded by freshwater lakes. I'm in a State surrounded by freshwater lakes. And as people hear the alarming statistics around the equivalent of a trash can or—excuse me, it's a dispensary of trash being dumped into the ocean per minute, that's alarming, going into the farthest trenches of our ocean and seeing that there's plastic waste there, that's not a result that any of us necessarily want to leave. But that's why I think we call it a plastic paradox because plastic has improved our lives. It has made it so that we can have food security and food delivered throughout our country and into the mouths of people and medical advancements.

But we've got to ask ourselves where and how we are going to meet this charge. Does it fully fall on the consumer? I believe there are individuals who want to step up and participate in recycling programs and find an altruistic value in doing so because they should and because they have a municipality that enables them to do that.

We have industry and public-private partnerships. We've got certainly great expertise that's researching this and understanding the chemical compounds. But we know we need to do better, and so we can turn to our colleagues throughout Federal Government and all of an interagency approach to meeting the technological considerations.

I think, Mr. Boven, we'd certainly like to continue to hear from you on the work that you are doing on the corporate side, but as it matches with what the National Institute of Standards and Technology is hopefully going to bring forward. And we will continue to partner with you and support you. I will say $3.2 million with Dr. Menon goes a long way.

The record on this hearing will remain open for 2 weeks for additional statements from Members and for any other additional questions that the Committee may ask of our witnesses.

At this time, our witnesses are excused, and the hearing is now adjourned.

[Whereupon, at 3:46 p.m., the Subcommittee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Govind Menon

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

"Closing the Loop: Emerging Technologies in Plastics Recycling"

Questions for the Record to:

Dr. Govind Menon
Director, School of Science and Technology
Chair, Department of Physics and Chemistry
Troy University

Submitted by Congressman Daniel Lipinski

Let me begin by thanking Chairwoman Stevens for giving me the opportunity to address the subcommittee on the pressing issue regarding the recycling of Plastics.

I would like to also thank Congressman Lipinski for bringing my attention to poignant NSF programs such as the I-Corps.

Question: How could entrepreneurial training programs, such as Innovation Corps, help academic researchers commercialize new recycling technologies?

Answer: The NSF I-Corps was established to support entrepreneurial education that helps researchers translate their academic knowhow to innovation that can attract third-party funding. Programs such as these, I believe, is the key piece of missing information that academics in a university setting suffer from. The vital techniques involved in connecting with industry partners will naturally lead to the development of new technology that will benefit the environment and reduce our carbon footprint. Additionally, this will alleviate our (research institutions') overdependence on federal help. Commercializing plastics recycling is particularly tricky because the profit margin is pennies to a pound. Yet, it has to be done. This is where *"a clear go/no go decision based on an assessment of the viability of the overall business model"* outcome of the NSF I-Corps program will be most beneficial.

Question: What are some other ways that the federal government can support entrepreneurs in transitioning academic recycling technology research to commercialization?

Answer: In addition to continuing to support research into the recycling of plastics, the federal government can help raise awareness for the need for plastics recycling. Initiatives that will bring cities and municipalities into this conversation can only help increase our supply of feedstock. A large scale buy-in of a recycling program by the general public is critical for success. Centers such as the CMMS at Troy University can help develop specific business models for the various stakeholders that will make the recycling of plastics economically viable. The federal government can help in deploying such strategies nationwide.

Responses by Dr. Gregg Beckham

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"Closing the Loop: Emerging Technologies in Plastics Recycling"

Dr. Gregg T. Beckham, Senior Research Fellow, National Bioenergy Center, National Renewable Energy Laboratory

Questions submitted by Chairwoman Haley Stevens

1. During the hearing there was a discussion about chemical recycling and how far along the United States is in the process of researching, developing and scaling a chemical recycling process that can be economically viable. How would you respond to the question about where we are on technology readiness, on a scale from 1 to 10? What recommendations do you have for what the Federal government can do to help develop chemical recycling technologies in the U.S.?

   Answer: In terms of scalable solutions for chemical recycling of all large-volume plastics, I think that we are at a 2 (with 10 being ready to scale and commercially viable).

   Today, plastics pyrolysis to produce monomers can be employed for some limited, clean plastics streams to produce monomers, but this technology is not widely practiced, and economic and life-cycle analyses and extensive product validation will be required to determine if this approach is actually viable. Moreover, significant technical challenges remain in high-temperature processing of plastics, including in the feeding of solid plastics to high-temperature, high-pressure reactors, dealing with heterogeneity in the plastics streams, and the impact of contaminants on the ability for recycling and upcycling of the resulting products.

   Gasification of plastics to produce synthesis gas (hydrogen and carbon monoxide) is also relatively mature from a technology development perspective, but it is typically thought that gasification will require huge scales to be economical, which plastics may not be able to achieve in an economically viable manner from a collection perspective to a centralized facility of sufficient size to be realistic. More analysis here is certainly needed as well.

   Why I believe we are at a 2 is because for more selective and robust chemical recycling and upcycling technologies, only a few demonstration plants are being built for specific single plastics now (such as polyethylene terephthalate), and it is not yet clear how sustainable and economically viable those pioneer strategies will be. Selective chemical recycling technologies (that are not pyrolysis or gasification) able to handle mixed plastic waste in many cases are still either conceptual or at a research scale, and the ability to handle both mixed and contaminated polymer waste streams will be critical for the design of a new chemical recycling industry in the U.S.

   Thus, research and development is urgently needed, guided by judicious economic and life-cycle analyses, to develop new approaches, new catalysts, and new processes to break down plastics selectively and either recycle them to virgin-like materials or upcycle them into higher-value components, and research and development efforts in this space are still very much in their infancy.

Moreover, beyond dedicated, sustained, and long-term funding for chemical plastics recycling research, development, and deployment, I strongly recommend that the Federal government approve plastic waste as a feedstock for research and development activities that can be funded by agencies such as the US Department of Energy. Specifically, offices such the BioEnergy Technologies Office in the Office of Energy Efficiency and Renewable Energy have invested huge amounts of research funds into the depolymerization and fractionation of plant biomass and other organic wet waste, and these learnings and the associated expertise from the research community can be directly applied to plastics. Changing the classification of plastics waste to be able to be worked on and funded by offices like the BioEnergy Technologies Office will accelerate work in this field and more effectively bring to bear the science and engineering expertise of the nation to this critical problem of plastics upcycling.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

"Closing the Loop: Emerging Technologies in Plastics Recycling"

Questions for the Record to:
Dr. Gregg Beckham
Senior Research Fellow
National Renewable Energy Laboratory
Submitted by Congressman Daniel Lipinski

1. Along with my colleague, Mr. Moolenaar, I recently introduced the House companion to the Sustainable Chemistry Research and Development Act. This legislation recognizes by the importance of sustainable chemistry principles in product design and materials transformation. How can sustainable chemistry principles be incorporated into the recycling process?

   Answer: Recycling and upcycling of plastics can directly address multiple aspects of sustainable (green) chemistry principles. Specifically, the twelve principles of Green Chemistry are:
   1. Prevent waste
   2. Atom economy
   3. Less hazardous synthesis
   4. Design benign chemicals
   5. Benign solvents and auxiliaries
   6. Design for energy efficiency
   7. Use of renewable feedstocks
   8. Reduce derivatives
   9. Catalysis (vs. stoichiometric)
   10. Design for degradation
   11. Real-time analysis for pollution prevention
   12. Inherently benign chemistry for accident prevention

   Certainly, recycling and upcycling of today's waste plastics could directly address the following 1) waste prevention (by keeping plastics out of landfills and the environment), 2) atom economy (by keeping plastics in a circular economy instead of a linear flow-through economy), 3) less hazardous synthesis (many recycling and upcycling strategies are less hazardous than the production process for virgin plastics), 6) design for energy efficiency (plastics recycling and upcycling is estimated to be able to save 40-90% of the inherent energy in plastics, and 9) catalysis (many advanced recycling technologies will use chemical and biological catalysis methods to break down plastics to their building blocks), likely among others.

   By redesigning "tomorrow's" plastics, the United States could also address simultaneously address 1) prevent waste (by reducing greenhouse gas emissions relative to today's plastics manufacturing), 3) less hazardous synthesis (through the use of renewably-sourced feedstocks like those from waste plant materials), 4) design benign chemicals (by replacing toxic compounds in today's plastics like bisphenol A with non-toxic compounds), 6) design for energy efficiency (by using bio-based and/or inherently recyclable plastics), 7) use of renewable feedstocks (by on-boarding plant-based and other renewably-sourced feedstocks to manufacture plastics), and 10) design for degradation (by developing compostable, chemically-recyclable, or biodegradable plastics), also likely among others.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

"Closing the Loop: Emerging Technologies in Plastics Recycling"

Questions for the Record to:
Dr. Gregg Beckham
Senior Research Fellow
National Renewable Energy Laboratory
Submitted by Congresswoman Suzanne Bonamici

1. According to a study in Nature Geoscience, earlier this month, researchers in France found thousands of microplastic are airborne and may be polluting the air that we breathe. Dr. Beckham, in your testimony you discuss the pervasive nature of microplastics in our society, from our soil to our food chain. What do we currently know about the effects of microplastics in our ecosystem? What research is needed to better understand the consequences for human health?

   Answer: To date, many reports have emerged that have attempted to quantify the amount, locations, and prevalence of microplastics in the natural and built environments and to understand the sources of these microplastics. However, much remains to be understood regarding the toxicological impacts of microplastics on overall ecosystem health, the effects on living organisms across the kingdoms of life, and the effect on human health specifically. Ecological, biological, and toxicological studies are urgently needed to further understand these issues and to quantify the impact that microplastics will have on the health of the planet and humankind.

2. Dr. Beckham, in your testimony you mention that "emissions from plastics combustion, beyond carbon dioxide, often contain toxic metals...causing yet another potential environmental cleanup problem while simultaneously adding to the amount of carbon dioxide in the atmosphere." How can Congress better support efforts to sustainably break down plastics in the recycling process?

   Answer: As mentioned during my testimony, research and development activities that harness the ingenuity of the United States research community are urgently needed to deliver new, innovative solutions for the United States recycling industry. The American Chemistry Council predicted in a 2019 study that the development of advanced recycling technologies would add 40,000 jobs and $10B to the US economy. Advanced chemical recycling strategies for plastics would also reduce domestic energy consumption and greenhouse gas emissions.

   I suggest that Congress can support research and development efforts in two major areas. First, the US research community needs support to develop robust and effective chemical recycling technologies that deal with the plastics that we manufacture today, most of which are not recycled and are landfilled after a single use. Developing methods to breakdown today's plastics and convert them into higher-value, useful materials with a second life (upcycling) will incentivize the reclamation of waste plastics in both the United States and around the world.

Second, Congress can also support the development of tomorrow's plastics, which should be inherently recyclable-by-design. By using renewably-sourced, bio-based materials such as waste plant materials, we have an opportunity to wholly redesign the polymer materials economy. The development of new building blocks for tomorrow's plastics will require sustained commitment to funding research and development in the bioeconomy sector, which could ultimately create many new jobs and a new industry for the United States.

Responses by Mr. Tim Boven to Representative Daniel Lipinski's questions

Question for the Record
Tim J. Boven, Recycling Commercial Director for the Americas,
Packaging & Specialty Plastics, Dow
Before the Subcommittee on Research & Technology
Committee on Science, Space and Technology
U.S. House of Representatives
Closing the Loop: Emerging Technologies in Plastic Recycling
April 30, 2019

1. **Along with my colleague, Mr. Moolenaar, I recently introduced the House companion to the Sustainable Chemistry Research and Development Act. This legislation recognizes by the importance of sustainable chemistry principles in product design and materials transformation. How can sustainable chemistry principles be incorporated into the recycling process?**

Sustainable chemistry principles[1] should be incorporated into every step of the recycling value chain and process. Products manufactured with plastic material need to be designed for minimization of material usage and integration into the recycling infrastructure upfront. This also includes eliminating when possible the use of materials that cannot be recycled easily within existing recycling chains. With regard to multi-material construction, designers need to minimize the use of incompatible materials. A good example is to avoid the use of paper labels and metal springs to plastic bottles. Fiber, in particular newsprint and paper used in packaging are difficult to separate out and will be contaminants in the plastic recycling stream. Even though these materials are recyclable when separated, they are not when comingled. The Associate of Plastic Recyclers (APR) has established guidelines[2] that should be considered. If a product is not designed to be recycled up front, the likelihood of it being recycled is reduced. The next step in the recycling value chain is the recycling process. When considering recycling processes, consideration of energy intensity and GHG should be evaluated and compared to the processes that they are replacing. It should be a comprehensive review that includes energy and emissions associated with the full process of waste collection, cleaning, pelletizing and distribution of the final product. We need to ensure that new value chains and processes that are being developed are not environmentally disadvantaged to the ones they are replacing.

[1] https://www.acs.org/content/acs/en/greenchemistry/principles/12-principles-of-green-chemistry.html

[2] https://plasticsrecycling.org/apr-design-guide/apr-design-guide-home

Appendix II

ADDITIONAL MATERIAL FOR THE RECORD

LETTER SUBMITTED BY REPRESENTATIVE HALEY STEVENS

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House of Representatives
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SUBCOMMITTEE ON HEALTH, EMPLOYMENT, LABOR & PENSIONS

SUBCOMMITTEE ON WORKFORCE PROTECTIONS

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

UNITED STATES HOUSE SCIENCE SUBCOMMITTEE ON ENERGY

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
CHAIR

April 29, 2019

The Honorable Andrew Wheeler
Administrator, U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington DC 20460

Dear Administrator Wheeler:

I am writing today to express my deep concern regarding the lack of national recycling and waste management infrastructure in the United States. The trash buildup in the U.S. and around the world following China's January 2018 ban on certain types of solid waste has drawn attention to how ill-prepared the U.S. is to handle the recyclable waste that we produce. As raw materials become scarcer and more expensive, a national recycling strategy would preserve our natural resources while driving economic growth to build American leadership in sustainable global innovation.

Recycling drives job creation in the collection and processing of materials, manufacturing new products from recycled materials, and remanufacturing. The International Trade Commission estimates that remanufacturing alone has already added over 180,000 jobs in the U.S., with an enormous potential for growth.

Another benefit of a national recycling system is reducing U.S. reliance on foreign imports of material used in domestic manufacturing. For example, rare earth elements are used for many commercial applications including electronic devices, automobiles, and national security applications, yet the U.S. relies almost entirely on imports from China for these finite resources. Rare earth elements and other critical minerals are also incredibly expensive, and a national recycling strategy will allow manufacturers to create good-as-new products at a lower cost.

The onus of waste management in the U.S. has historically fallen on state and local governments. As waste management companies are no longer able to sell recyclables to China, they are driving up their pricing to recoup costs. In many cases, U.S. cities are being forced to cut longstanding recycling programs and are instead incinerating recyclables or leaving them in landfills, releasing harmful dioxins, methane and other dangerous emissions. For example, the

Detroit Incinerator, the largest municipal solid waste incinerator in Michigan, has exceeded emissions limits more than 750 times since 2013.

The latest data from the EPA shows that in one year, recycling, composting, combustion with energy recovery and landfilling prevented over 181.5 million metric tons of carbon dioxide equivalent of greenhouse gas emissions, which is comparable to the annual emissions from over 38.8 million passenger vehicles.

We know the enormous environmental and economic benefits of recycling, and we know that there is a great need for action at the federal level. I am requesting detailed responses to the below questions.

- Why has data on the generation, recycling, composting, energy recovery and landfilling of materials and products in the United States not been updated since 2015?
- What steps, if any, is the Environmental Protection Agency taking to build out the national recycling infrastructure of the United States?
- How is the EPA working to mitigate the ongoing impacts of China's plastic ban and the resulting market costs for U.S. cities and states?

Thank you for your attention to this matter. I look forward to working with you to improve our nation's recycling infrastructure and to ensure the United States can best utilize our resources to remain competitive and maintain our natural beauty.

Sincerely,

Haley M. Stevens
Member of Congress

LETTERS SUBMITTED BY REPRESENTATIVE JIM BAIRD

PEPSICO

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May 1, 2019

The Honorable Haley Stevens
Chairwoman
House Science, Space and
Technology Committee
Subcommittee on Research
and Technology

The Honorable Jim Baird
Ranking Member
House Science, Space and
Technology Committee
Subcommittee on Research
and Technology

Dear Chairwoman Stevens and Ranking Member Baird,

Thank you for holding the hearing this week entitled, "Closing the Loop: Emerging Technologies in Plastic Recycling." This is an important topic, and we believe it is an area where the public and private and sector can work together to promote new ideas and technologies to improve recycling.

Recycling is a key part of PepsiCo's "sustainable plastics vision" of building a world where plastics need bever become waste. We strive to support recycling wherever we do business, and as a U.S.-based company with significant operations, sales and local presence in cities and towns across the country, including over 100,000 employees, we have a special responsibility to do our part for U.S. recycling.

At PepsiCo, we are helping to increase recycling rates by investing in consumer education and local recycling infrastructure. We created our own PepsiCo Recycling program to test new approaches to recycling and expand relationships through over 600 programs with municipalities and commercial sites. In 2010, we launched Recycle Rally, an initiative that engages teachers and educates students about recycling. More than 6,000 schools– have participated in Recycle Rally over the past nine years to collect more than 400 million plastic bottles and aluminum cans.

In 2014, we became a founding member of the Closed Loop Fund, which is seeking to invest $100 million by 2020 to raise recycling rates in the U.S., including improved curbside recycling infrastructure and materials sortation and re-processing. To date, the fund has invested in 17 projects across the U.S. and Canada. These investments range from a project in Nebraska with the state's largest full-service recycler returning more than 120,000 tons of recyclables to the supply chain, to a project with the City of Memphis to introduce universal curbside recycling to residents, improving access to more than 100,000 households, recovering more than 160,000 tons of recyclables, and saving the city more than $4 million in landfill tipping fees. Since 2014, PepsiCo has invested $3 million in the fund.

In 2018, we made a $10 million grant to The Recycling Partnership to launch "All in On Recycling," an industry-wide challenge to raise $25 million to improve recycling for 25 million families across the country, while supporting a circular economy, simplifying recycling and creating stronger, cleaner communities. In addition to contributions from other corporations, the more than 2,800 communities that participate in the initiative are expected to triple the collective investment, catalyzing roughly $75 million in municipal funding, and bringing the total amount of support to $100 million.

As part of our effort to move towards 100 percent recyclable, compostable, or biodegradeable packaging, we successfully converted non-recyclable pressure-sensitive labels on all 89- and 118-ounce Tropicana products. Additionally, in 2018 PepsiCo joined The NaturALL Bottle Alliance, a research consortium with consumer packaged goods industry leaders and a bio-based materials development company, Origin Materials, to accelerate the development of innovative packaging solutions made with sustainable and renewable resources, including post-consumer cardboard, thus creating additional end market demand for this material.

To support our effort to reach 25 percent recycled content in our products, in 2018 PepsiCo entered into a multi-year supply agreement with Loop™ Industries to purchase production capacity from Loop's joint venture facility in the U.S. and incorporate Loop™ PET plastic, which is 100 percent recycled material, into our product packaging by mid-2020. Loop's transformational chemical recycling technology allows now low-value plastics to be diverted, recovered and recycled continuously into new, virgin-quality plastic. This means that plastic bottles and packaging of any color, transparency or condition, as well as carpet, clothing and other polyester textiles that may contain colors, dyes or additives, and even ocean plastics that have been degraded by sun and salt can be converted into food-grade packaging.

Most recently, we signed a national pledge along with partners across the supply chain to work with the U.S. Environmental Protection Agency to develop a national strategy on recycling rates that includes four action areas: enhance recycling infrastructure, create new markets for recycled materials, improve public education regarding recycling, and enhance measurement.

PepsiCo is firmly committed to being a leading force in the industry-wide push for better recycling and sustainable packaging in the U.S. and believe our actions have had and will continue to have a meaningful impact. We would like to reiterate our support for continued discussions and thank the committee for its important work on the subject. Specifically, we would like to offer our team and expertise to the committee to help shape their future plans and recommendations so that together, we can improve US recycling rates and reduce the loss of valuable plastics to landfills and the environment.

Respectfully,

Tim Carey
Senior Director, Sustainability
PepsiCo

PLASTICS
INDUSTRY ASSOCIATION

May 9, 2019

The Honorable Haley Stevens, Chair
Committee on Science, Space and Technology
Subcommittee on Research and Technology
2321 Rayburn House Office Building
Washington, DC 20515

The Honorable Jim Baird, Ranking
Committee on Science, Space and Technology
Subcommittee on Research and Technology
2321 Rayburn House Office Building
Washington, DC 20515

Dear Chairwoman Stevens, Ranking Member Baird and Members of the Subcommittee on Research and Technology,

The Plastics Industry Association (PLASTICS) applauds the House Committee on Science, Space & Technology for holding a hearing on innovation and emerging technologies in recycling—a vital topic that has a role to play in our nation's response to the crisis of plastics entering into the environment. We thank all of the witnesses, particularly Mr. Tim Boven, recycling commercial director of packaging & specialty plastics for Dow, one of our organization's most dedicated member companies.

PLASTICS believes that, in many ways, we can have an impact on the current challenge facing plastics recycling by simply adding more—more facilities, more machines, more bins, more sorters and more collection points. Investment in our nation's waste management and recycling infrastructure should certainly expand the opportunities that every consumer has to recycle their plastic products regardless of where they are or what their product is made of.

But it's crucial that in the process of asking how we can recycle more, we also ask ourselves how we can recycle better. Every witness at this hearing nodded to the fact that investments in chemical or feedstock recycling have the potential to not merely find a use for plastics that have reached the end of their life—which, of course, is preferable to them ending up in the landfill or, even worse, littered—but to find a higher, even more valuable use for these plastics—such as turning bottles into car parts and bottle caps into food packaging.

By finding a way to increase the value of these materials at end of life, we can make the recycling process more profitable and less prone to pricing swings. We can also innovate to identify new ways to collect difficult to capture plastic

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products and ultimately put them to a better use. By expanding not only our capacity, but our capabilities to handle our scrap, we can truly manage these materials as resources, which is what they are.

PLASTICS has always believed in finding market-based solutions to our environmental challenges, and in this case the preponderance of recyclable plastic materials here in the U.S. presents an enormous economic—and environmentally beneficial—opportunity to the public, the research community and the industry. As such, PLASTICS has worked both to develop ways to capture unrecycled plastics and to create reliable markets for the collected materials:

End of Life Vehicle (ELV) Recycling Project – This seminal demonstration project has entered its third and final stage, which will focus on the potential of scaling up collection and recovery of plastic car and truck bumpers across the U.S. Phase II focused on recovering this material from auto shredders, which proved economically challenging. Phase III will instead focus on scaling up recovery among auto body repair shops and collision centers—businesses already removing the bumpers for other repairs. Phase II did successfully demonstrate the consistency in quality of material that can be obtained from different samples for ELV bumpers. With proven quality and performance, recyclers participating in this demonstration project are working with customers to develop new end markets for these materials.

New End Market Opportunities (NEMO) for Film – The NEMO Film project is also entering its third and final phase which will focus on finding end-market opportunities in asphalt, building and construction, non-food contact packaging, and agricultural plastics for plastic wraps, bags and films. Significant progress has been made in asphalt evaluation, including preliminary testing that showed a significant improvement in the temperature failure rate for asphalt containing a 3% blend of PE-NEMO film.

Positive initial results suggest that further testing is warranted. PLASTICS has entered a final phase of research with the National Center for Asphalt Technology, which will yield the performance information necessary to begin to take this formulation to demonstration in private applications.

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The National Asphalt and Pavement Association has been working with us closely on this effort, as well as other universities and groups involved in asphalt including Texas A&M.

Materials Recovery for the Future (MRFF) – The MRFF project is a multi-year industry-funded effort to prove out the collection of flexible plastic packaging through curbside programs and the ability to effectively sort that material into a valuable commodity at a materials recovery facility (MRF). Phase I and Phase II of the project demonstrated the feasibility of collection and sorting with the right configuration of equipment. We kicked off Phase III in June 2018 with the announcement of a multi-million dollar investment to retrofit the Total Recycle MRF in Berks County, Pennsylvania. Equipment installation was finalized in December 2018. Sortation testing will occur through June 2019, and full-scale collection and recovery of flexible plastic packaging is scheduled to begin in summer 2019.

If successful, this demonstration project will serve as a model for future MRF modernization to accommodate the evolving packaging stream and greatly increase the recovery of plastic packaging.

These projects are noteworthy, but only scratch the surface of what the industry is working on to make plastics recycling more widespread, more profitable and more reliable. Dow's efforts to develop depolymerization and other feedstock recycling technologies is a sterling example, but hardly the only one as companies large and small rise to the task of helping the world not only recycle more, but recycle better.

Innovation and investment will be the twin pillars that support this effort to shift the plastics economy from a linear model to a circular one. Innovation, of course, also requires investment—the academic, corporate and consumer universes will all have a part to play in discovering what works, how we can scale it across the entire U.S. in a way that it is positioned to not only handle the scrap materials of today, but of tomorrow as well. By building a robust domestic recycling infrastructure, we ensure that our recycling markets stay insulated from shifts in global demand, pricing or packaging preferences. The work is well underway to find the newest technologies that suit today's plastics economy and PLASTICS welcomes the opportunity to work with policymakers to ensure that this work bears fruit.

It's no secret that the largest contributor, globally, to marine litter is not the United States, so why have this conversation here? Well, in the U.S., the states have historically been known as the laboratories of democracy. Globally, the U.S. has often been the laboratory of ideas and technologies that make the world a better place. The challenge facing us will only be solved through a combination of investment, innovation, collaboration and, of course, American leadership. Together we can create a new materials recovery model that can be successfully implemented here, and then exported like so many other American ideals to other countries to strike a truly global solution to a truly global problem.

We look forward to working with Congress and the Administration to advance these goals and stand ready to provide any additional resources or information they might require.

Sincerely,

Patricia D. Long

Patty Long
Interim President & CEO
Plastics Industry Association (PLASTICS)

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Classification: General Business Use

CLOSING THE LOOP: EMERGING TECHNOLOGIES IN PLASTICS RECYCLING

April 29, 2019

The Honorable Haley Stevens
227 Cannon HOB
Washington, DC 20515

The Honorable Jim Baird
532 Cannon HOB
Washington, DC 20515

Subject: Support for Chemical Recycling and Recycling Infrastructure

Dear Chairwoman Stevens, Ranking Member Baird and Members of the Subcommittee on Research and Technology,

SABIC is a global chemicals company with a long-term presence in the United States of America, and a strong growth agenda based on product and feedstock diversification. As a company that manufactures materials, our strategy aims to keep plastics within the materials value chain, and we are taking leading action on chemical recycling, which we see as an important component of a transition to a circular economy. Support for chemical recycling can help create jobs and revenue while keeping valuable plastic resources out of landfills by converting them back into valuable feedstock for the petrochemical industry

In 2018, we announced the development of the world's first demo-plant (in the Netherlands) to refine and upgrade waste plastic for use in commercial manufacturing. SABIC is partnering with a plastic-to-oil company that converts low-quality, mixed plastic waste otherwise destined for incineration or landfill into a synthetic oil that can be used as a feedstock into our plastic process. We are funding a project to refine and upgrade the oil so that it can be used for the production of traditional petrochemicals. This project marks a significant milestone for SABIC's efforts to build a circular economy, and is expected to enter commercial production in 2021.

Post-consumer plastics are too valuable a material to waste. Legislation and research supporting chemical recycling can help create an enabling and welcoming environment for businesses to create jobs and revenue by keeping plastic resources out of landfills and converting them back into valuable feedstock for the petrochemical industry. A recent American Chemistry Council study on the economic impact of advanced plastics recycling shows there is potential for the creation of as many as 9,400 direct jobs and as much as $4.1 billion in direct economic output per year:

https://www.plasticsnews.com/article/20190422/NEWS/190429997/acc-pushes-chemical-recycling-legislation

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The plastics industry is making a push in states for new laws at the state level to make it easier to build next-generation recycling plants that turn waste plastics into feedstock and fuels, and we recently secured legislative victories in Iowa and Tennessee.

The new laws sought by plastics companies and the American Chemistry Council, of which SABIC is an active member, would regulate the plants as manufacturing operations, rather than landfills or solid waste disposal facilities, making it easier for new facilities to get government approvals.

The push in state governments is linked to the industry's broader $1.5 billion Alliance to End Plastic Waste. Research into chemical recycling is a key part of the initiative's attempt to find viable markets for hard-to-recycle plastics.

Infrastructure Investment

https://www.plasticsindustry.org/sites/default/files/Recycling%20Infrastructure%20Letter.pdf

SABIC encourages Congress to develop and advance an infrastructure investment package that includes and expands upon opportunities in solid waste management and recycling to improve our national infrastructure, promote sustainable development and create jobs. We believe strongly that a federal investment targeting recycling and recycled materials is critical to America's economic success, will yield environmental benefits, and will create jobs throughout the United States.

Recent decisions by China to reduce or end the importation of scrap material from other nations are disrupting recycling programs throughout the United States, and make it more critical that we make new investments in domestic recycling capacity. Without significant investment in such capacity, millions more tons of otherwise recoverable and recyclable material will be lost to landfills each year. This material is a commodity that can be at the forefront of advances in sustainability. For example, as companies strive to meet global targets for waste diversion or increased use of post-consumer recycled materials, they need a reliable and steady long-term supply of recoverable and recyclable materials to make the necessary advances in packaging in order to meet those targets.

We urge support for including the following concepts in any federal infrastructure legislation that is developed:

- Retrofitting Material Recovery Facilities (MRFs) with advanced sorting equipment that can identify and properly handle a wider range of packaging forms, including flexible film and smaller items made of otherwise recyclable material.
- Quicker permitting of MRFs, plastics recycling facilities, and conversion technology (chemical recycling) facilities that advance responsible environmental standards, creating valuable chemicals and energy products that produce positive environmental impacts while creating additional capacity.
- Increased use of recycled material in infrastructure projects where appropriate.
- Broadened use of private activity bonds for recycling projects.
- Incentive grants for state and local governments to expand curbside recycling options and the range of materials collected - Providing access to curbside recycling to all U.S. residents (less than half of Americans presently have the same level of access to curbside recycling as trash collection) will standardize the types of material that can be and are recovered across the country.
- Education and training to improve understanding of what is recyclable, and to promote the job creation aspect of the recycling process that will support American manufacturing jobs, the U.S. economy and the environment.

Alliance to End Plastic Waste

SABIC has long been engaged in our industry's efforts to reduce plastic waste. From 2014 to 2018, we chaired the World Plastics Council, a global, industry-led effort to develop sustainable solutions to marine debris. Supporting the growth and development of a circular economy, one in which products and raw materials are not wasted, but rather used to create new, valuable products, is a key goal of SABIC's sustainability platform.

This year, we stepped up our impact by becoming a founding member of the Alliance to End Plastic Waste (AEPW). This new non-profit organization, consisting of global companies across the chemical-and-plastic value chain, will bring collective knowledge, resources, and experience together to address plastic waste leaking into the environment. The AEPW has ambitious targets to work with governments, multilateral institutions, companies, non-government organizations, and communities to support investments and programs over the next five years.

We are targeting four key areas:

- Infrastructure development to manage waste and increase recycling.
- Innovation to develop and bring to scale materials, product designs, and new recycling technologies that minimize waste and create value from post-use plastics.
- Education and engagement to enlist governments, communities, businesses, and individuals in the movement.
- Cleanup of concentrated areas of waste in the environment, particularly in rivers that carry land-based waste to the sea.

As no one company, country, or community can solve this issue on its own, SABIC is committed to working with other Alliance members around the world.

We appreciate the opportunity to share the story of our chemical recycling innovations with the Committee and we look forward to future opportunities to convey our desire to grow our business in America while maximizing social benefits from our use of natural resources.

Sincerely,

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