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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*  
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## 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.<sup>1</sup> 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.

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<sup>1</sup> <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.<sup>2</sup> 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.

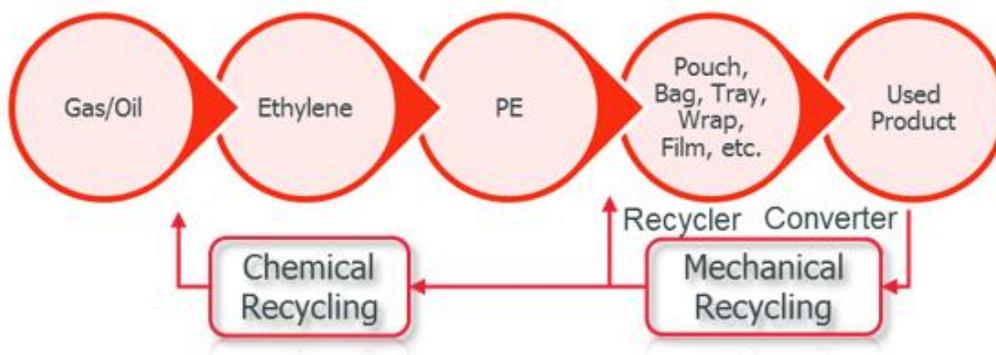
### **Plastic Recycling Processes**

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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<sup>2</sup> <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.<sup>3</sup> 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 compatibilization 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

<sup>3</sup> <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 contaminants 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 solvolysis 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.<sup>4</sup> 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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<sup>4</sup> <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 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.