

# Driving Green In the Automotive Industry

Debbie Mielewski, Ph.D.  
Retired Technical Fellow, Sustainability & Emerging Materials  
Ford Motor Company

Sustainability Entrepreneur, Dione Solutions, LLC

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[Debbie@dionesolutions.com](mailto:Debbie@dionesolutions.com)

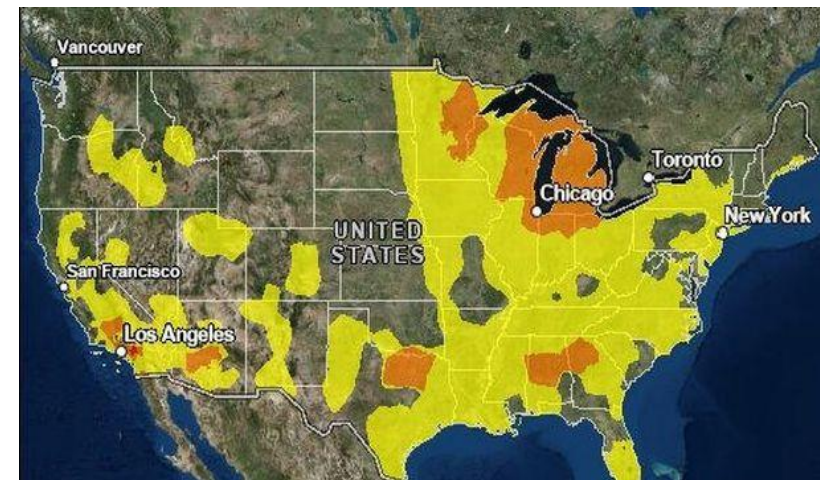




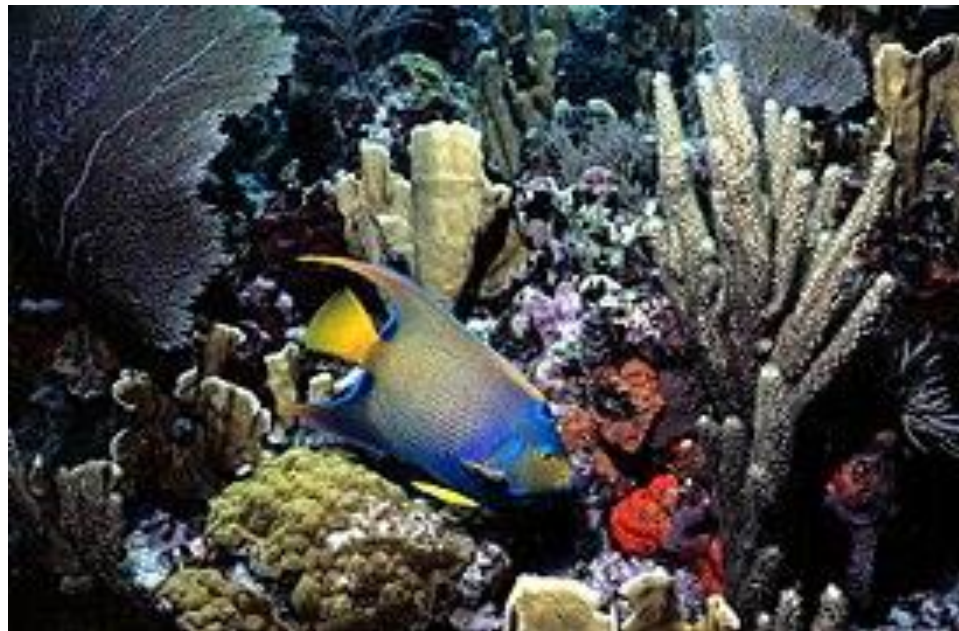
# What Is Happening?



The air quality forecast map for the US, July 25



AirNow







# A Planet in Crisis

Biodiversity loss

Plastic Pollution

Deforestation

Air Pollution

Global Warming

Melting Icecaps

Acidification of Oceans



And it's not like we didn't have  
warning...  
knowledge does not ensure  
good decision making

# The Rodney & Otamatea Times

WAITEMATA & KAIPARA GAZETTE.

PRICE—10s per annum in advance

WARKWORTH, WEDNESDAY, AUGUST 14, 1912.

3d. per Copy.

## Science Notes and News.

### COAL CONSUMPTION AFFECT- ING CLIMATE.

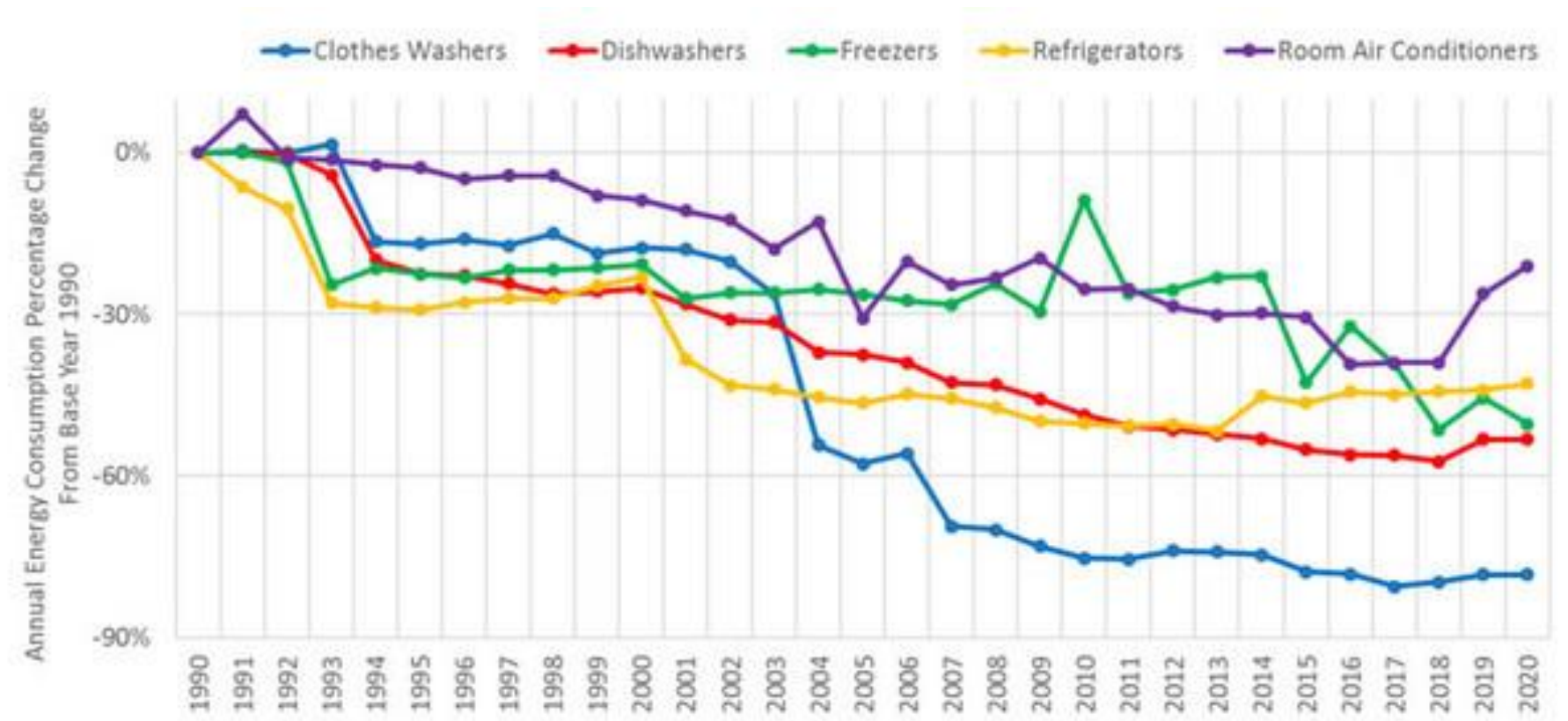
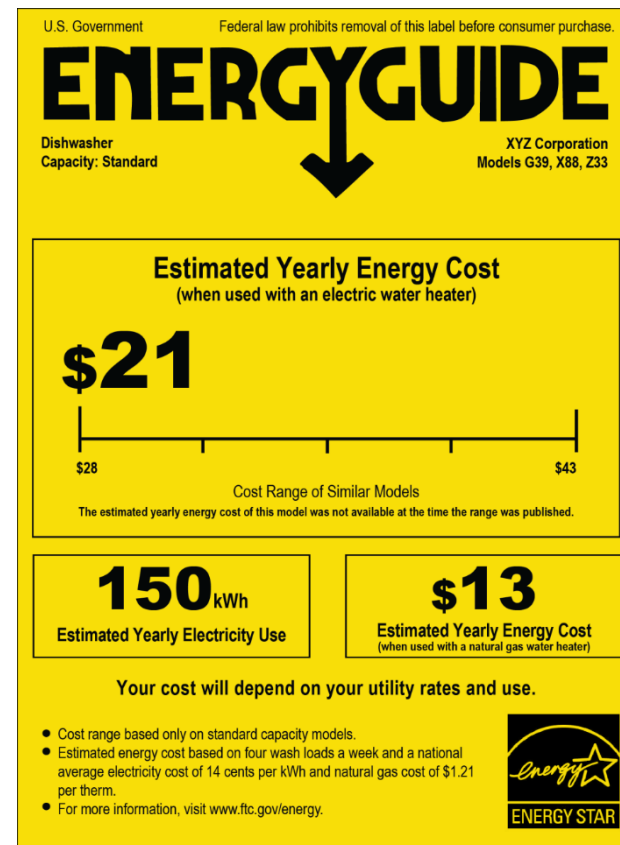
The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.



# Home Appliance Industry Committed to Climate Action & Sustainability



- The first appliance labeling rule was established in 1979
- All products were required to carry the label starting in 1980
- Label details how much energy used compared to similar models and cost to run them



Energy consumption of appliances versus time

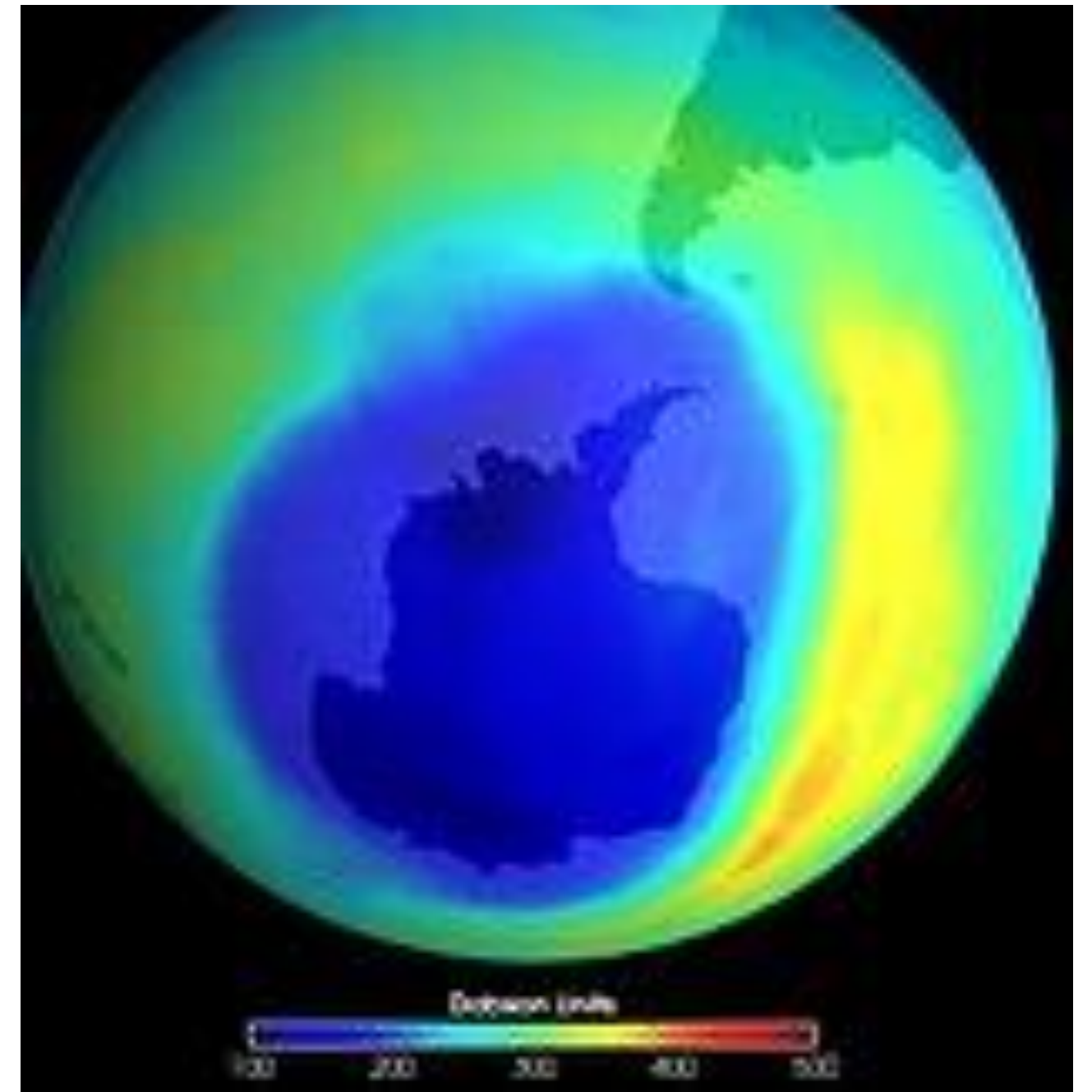
Graph from: Association of Home Appliance Manufacturers





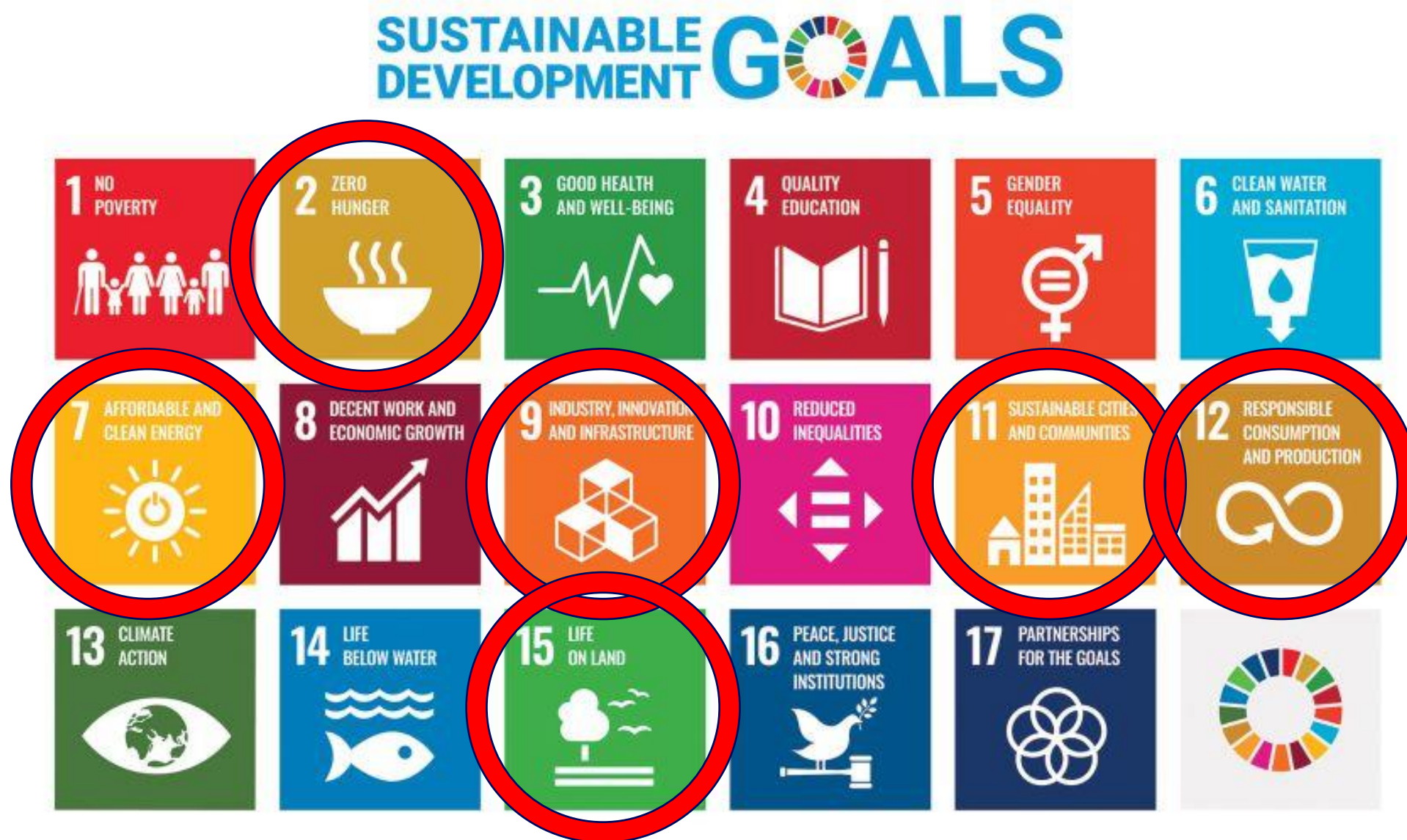
# Healing the Ozone Layer—CFCs Maybe our Biggest Environmental Success to Date

- Scientists discovered the ozone hole in 1985 (published May 16, Nature) and determined that CFCs (solvents and refrigerants) cause
- Predicted that increased levels of UVB would increase skin cancer
- An international agreement, the Montreal Protocol of 1987 pledged to phase out CFCs beginning in January 1989. All 197 members of the UN ratified it and 99% of ozone depleting CFCs and HFCs have been eliminated
- The ozone layer has been steadily improving and could heal by 2040
- When the world works together, problems can be solved!





# The Paris Climate Agreement and the U.N. SDGs



- 195 countries agreed to agenda
- 17 global goals for improving planet and quality of human life by 2030
- Relies on private business sector to voluntarily change unsustainable production/consumption
- GHG emissions need to peak before 2025 and decline 43% by 2030
- Predictions estimate 14% increase by 2030
- Progress made, but not nearly fast enough to meet goals

\*Image courtesy of United Nations



**Biden sets U.S.  
goal to replace  
90% of plastics  
with  
biomaterials,  
March 22, 2023**

- Bold goals for U.S. to be a leader in the bioeconomy
- Demonstrate and deploy cost-effective and sustainable routes to convert bio-based feedstocks into recyclable-by-design polymers, replacing 90 percent of plastics
- Redesign plastics to improve end-of-life properties like recyclability and compostability,
- Goal of 30% of U.S. chemicals from biomanufacturing



# Sustainable Material Sources

## BIO-BASED FOAMS – DISPLACES USE OF OIL



palm



rapeseed



soy



castor

## NATURAL FIBER COMPOSITES – DISPLACES USE OF FINITE RESOURCES

coconut



wheat straw



cellulose

## RECYCLED MATERIALS – REDUCES LANDFILL WASTE, DISPLACES USE OF OIL

jeans



bottles



money



## BIO-BASED RESINS – DISPLACES USE OF OIL

corn



algae



sugarcane

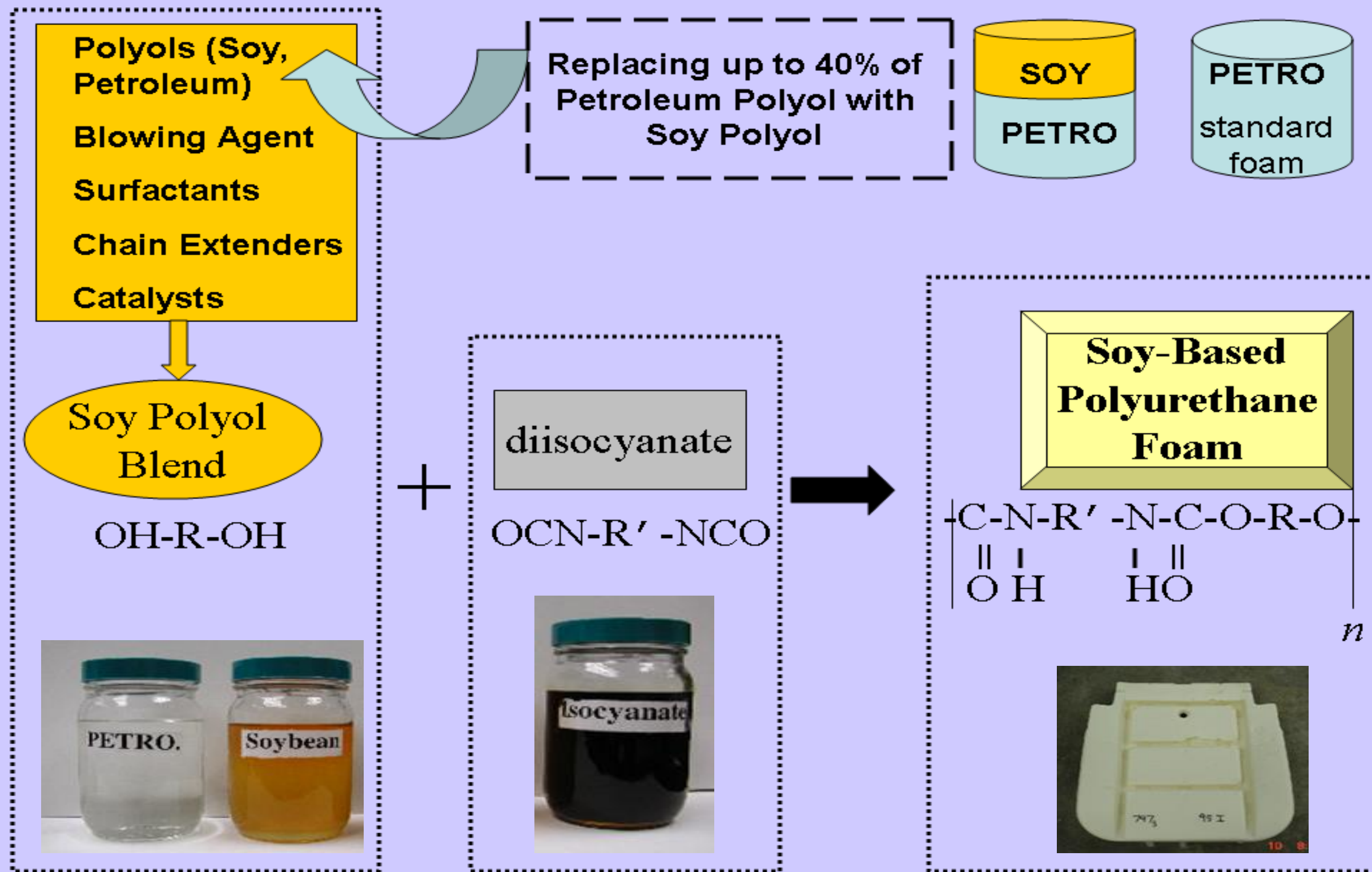


dandelion



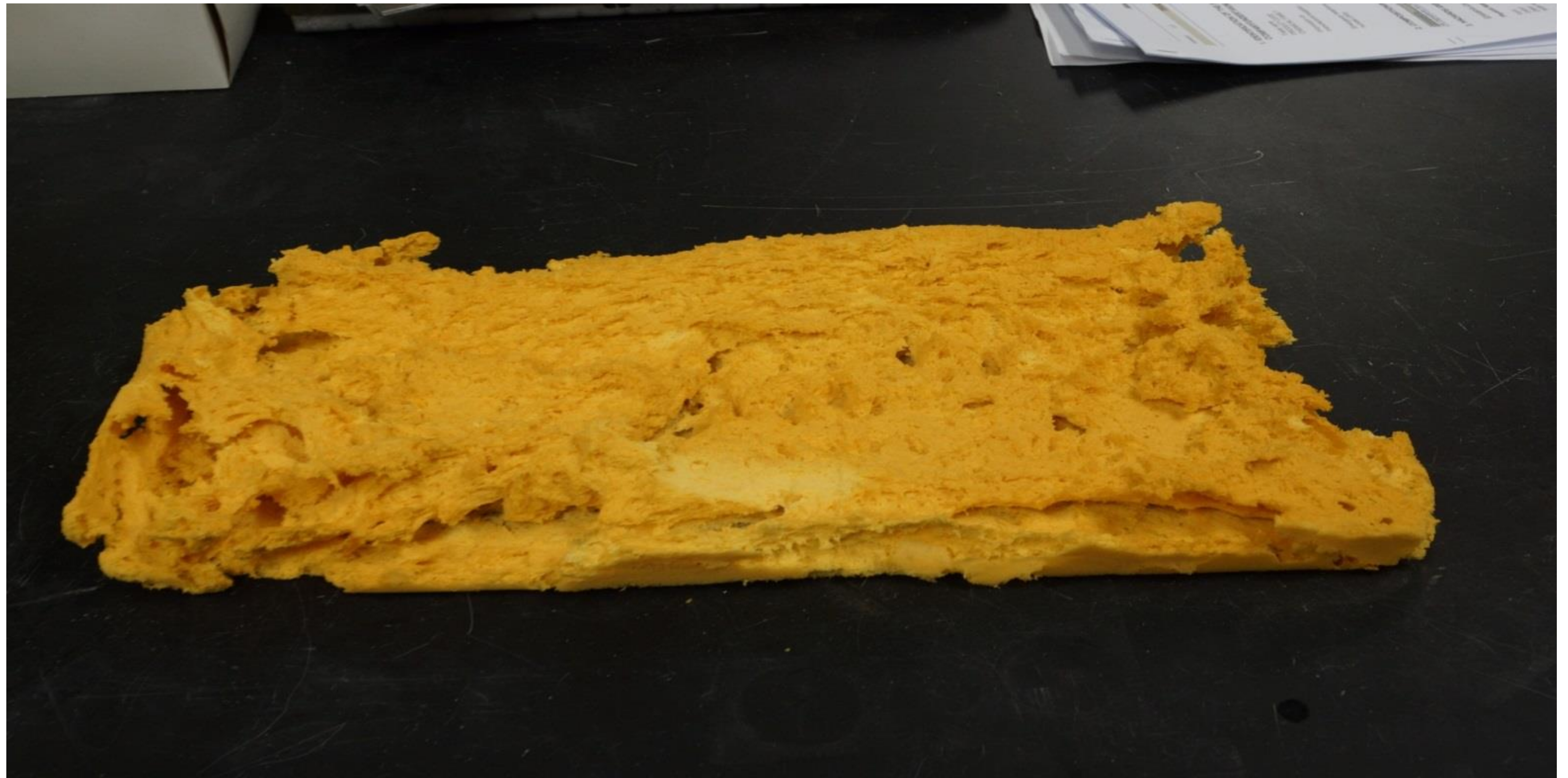


# Our First Success: Soy Foam





Never Expect Easy: One of the first soy foams.





# Key Technical Challenges

- **Formulations:**

- Optimizing formulation for levels of soy
- Balancing gel/blow reactions
- Blend stability between bio and petrol-polyols

- **Odor:**

- Odor of blown soy oil and foam

- **Properties:**

- Pass all material specifications
- Meeting performance requirements

## Screening Tests

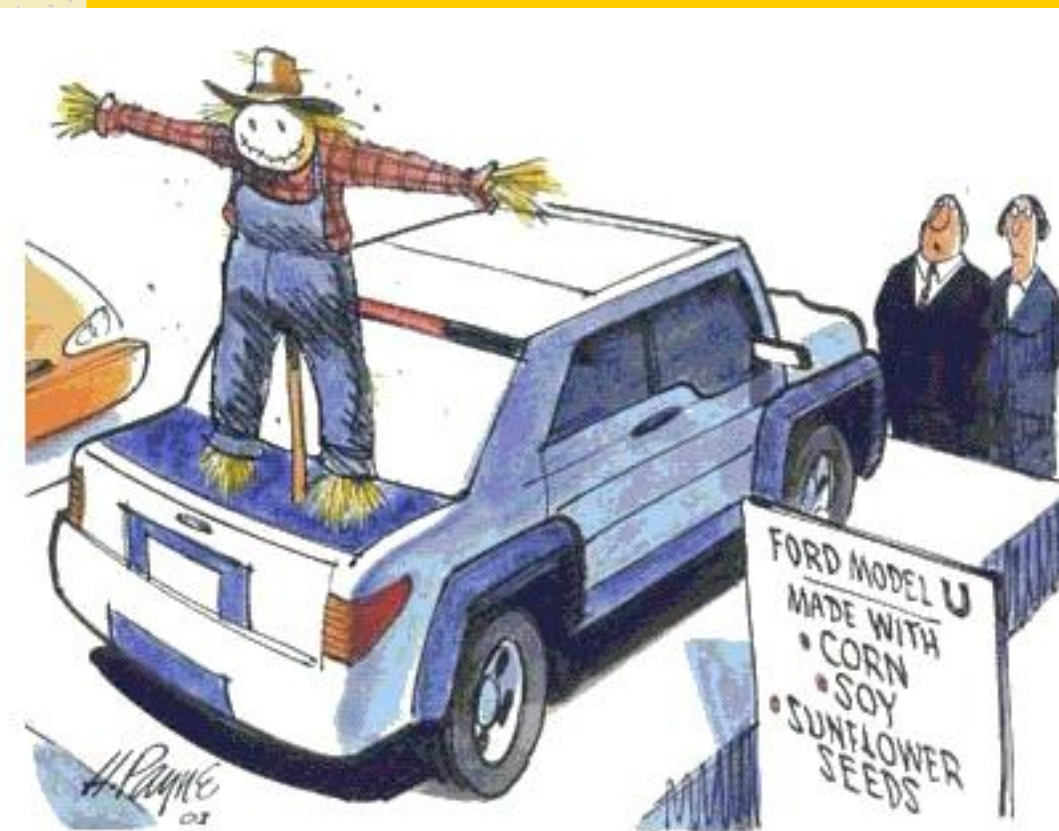
- Density
- Optical Microscopy
- Tensile Strength, Elongation
- Compressive Modulus
- Tear Resistance
- Compression Set  
(50% deflection at 70°C, 22hrs.)
- Fogging
- Odor



# Demonstrating Biomaterials on 2003 Model "U"



## Positive Press on Model U



*"With all the crop-based materials, we added a scarecrow option to keep the crows away."*

Henry Payne,  
Detroit Free Press

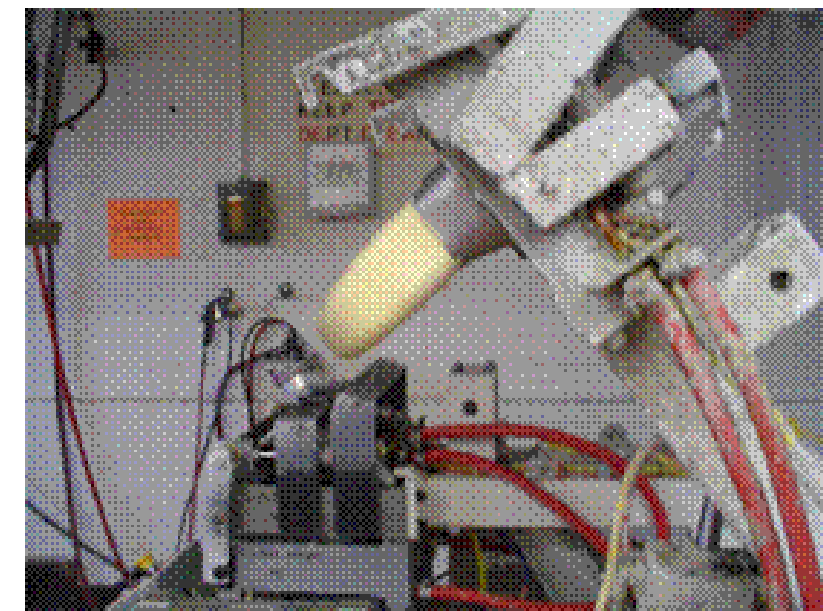
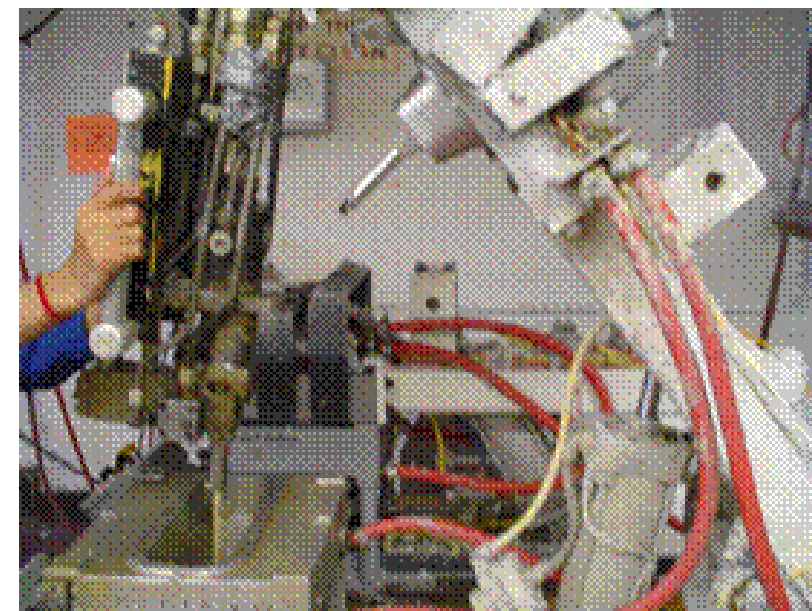
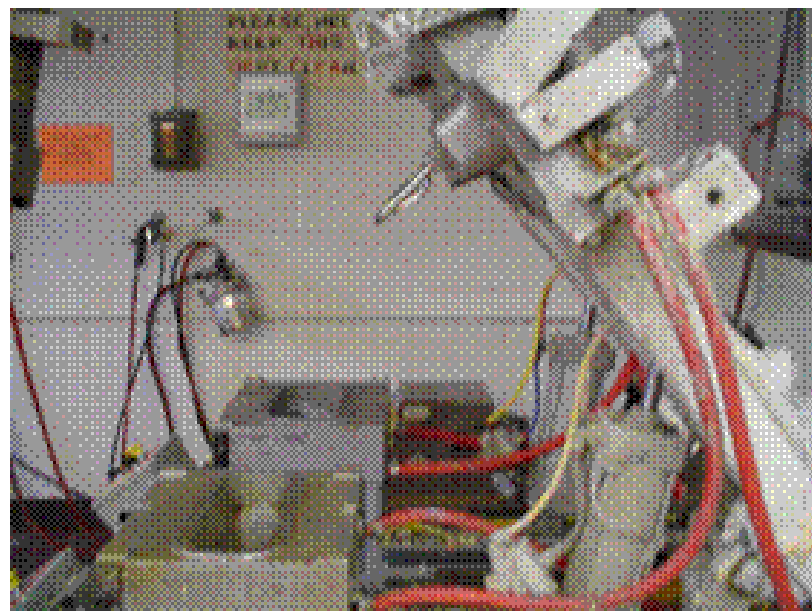


Research & Advanced Engineering



# Processing Optimization for Soy Foam Headrests

- ✦ Optimized formulations and processing conditions
  - ✦ Cycle Time: meets production requirement
  - ✦ Reactivity profile meets manufacturing setup
  - ✦ Molded HR meets production level quality
- ✦ Issues identified: blend separation, surface skinning, tear resistance





# Business Considerations

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## 1<sup>st</sup> implementer paving the way

- Materials specifications
- Program support

## Cost evaluation of final product

- Quantity of material needed

## Plant complexity

- Additional chemical line or tank (\$)
- Multiple OEM products

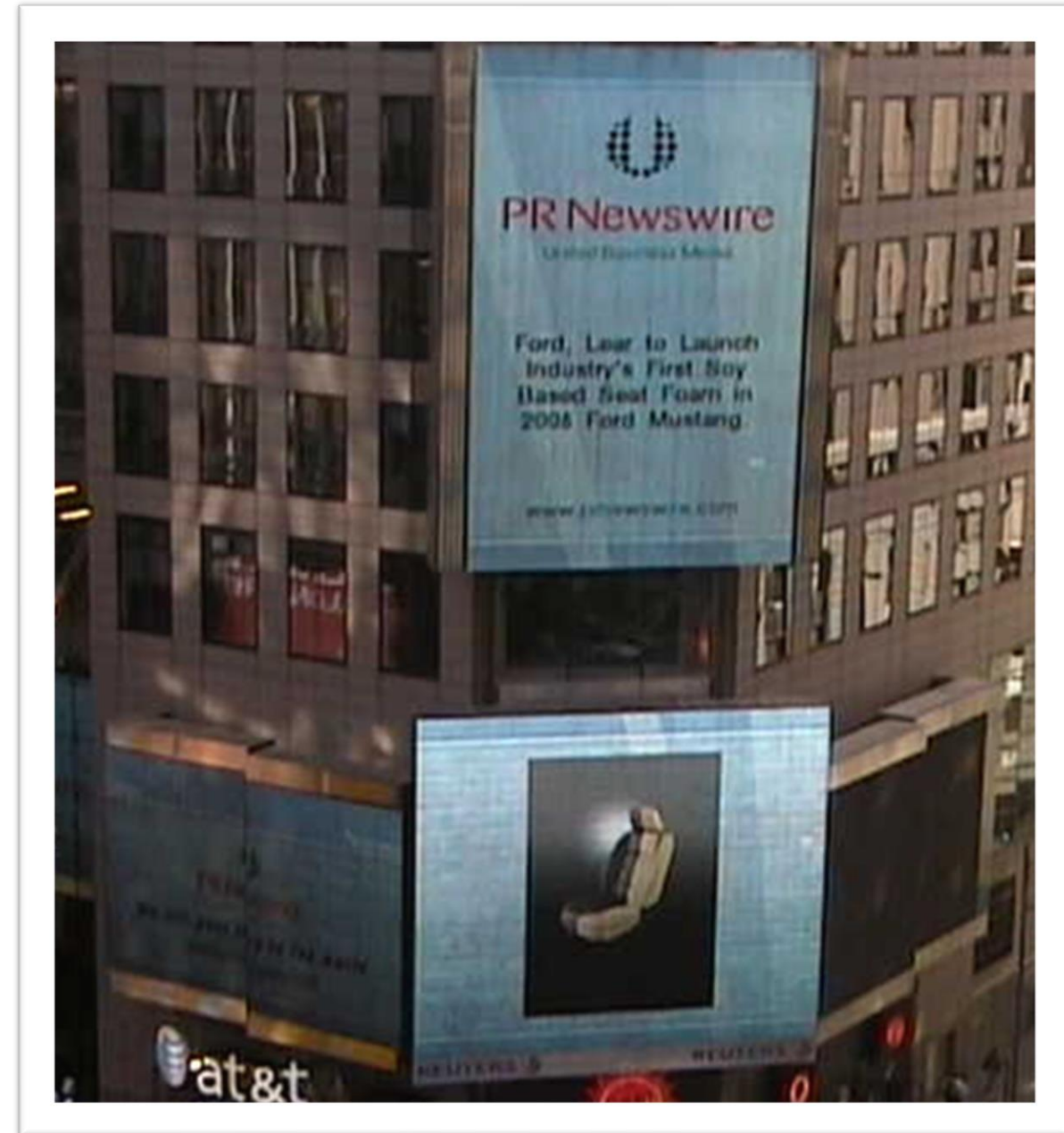
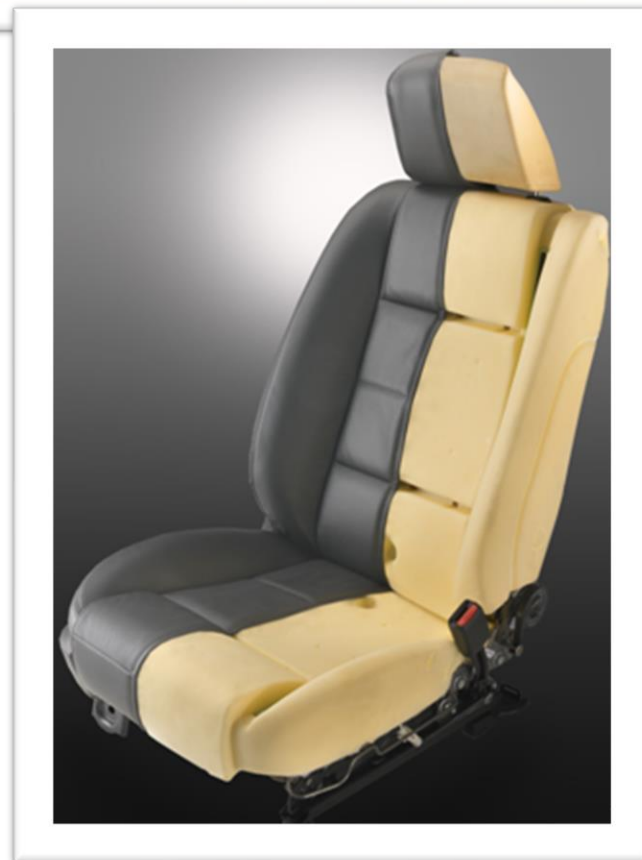
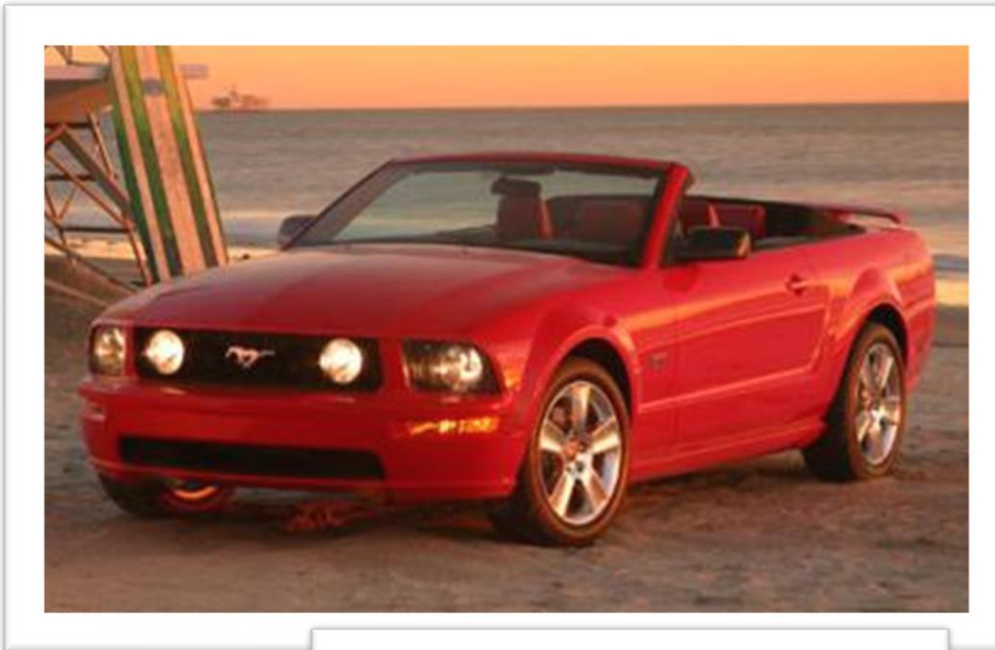
## Supply chain availability

- Who makes the material?





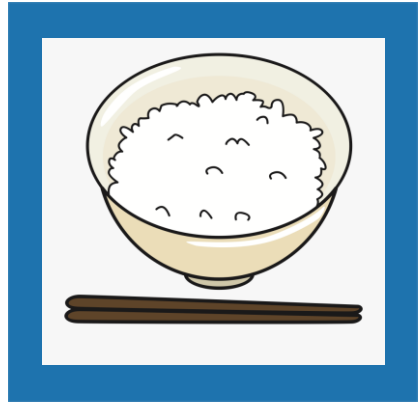
# Implementation of Soy Foam on 2008 Mustang



**There are 31,251 soybeans used in a typical vehicle for seat cushions and backs**



# ImAGination

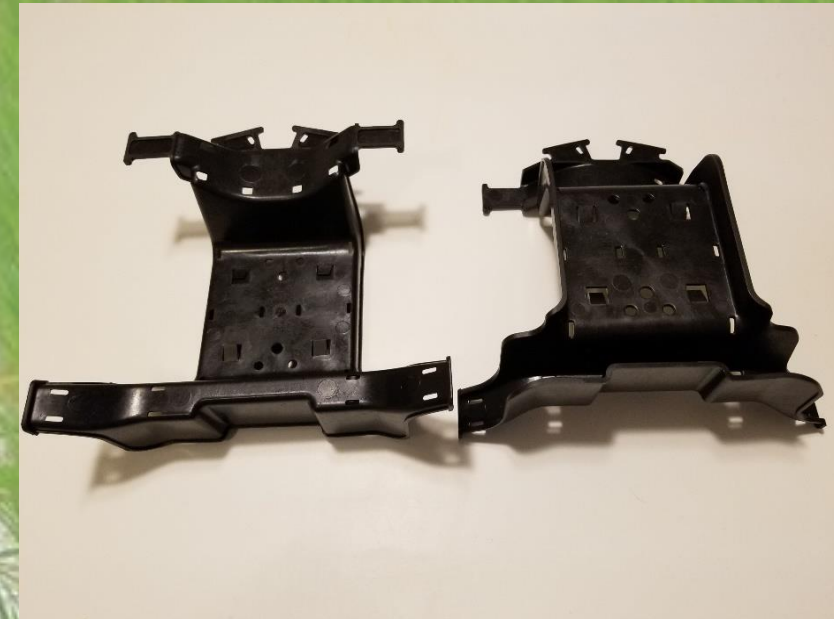


☐ Significantly reducing CO2 emissions

☐ Reduce the energy costs associated with production

☐ Extra revenue sources for the farmers

# Rice Hull filled PP





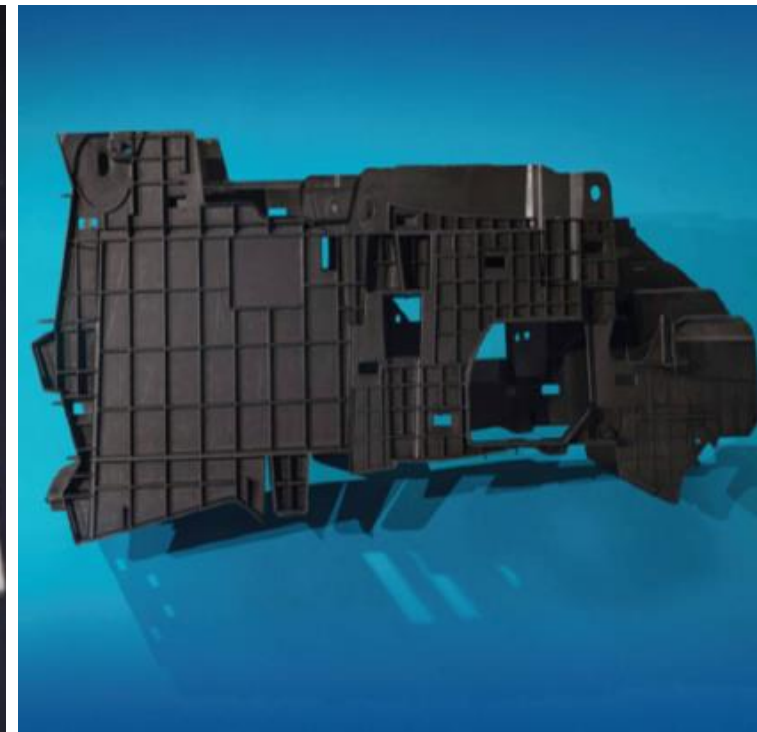
# We Should Be Inspired by Trees

- Excellent mechanical properties
- Lower density/lightweight
- Renewable
- Lower process T & reduced cycle time
- More isotropic
- Lower environmental impact

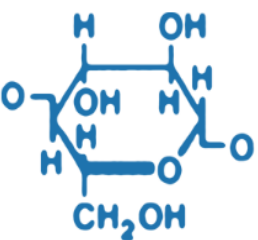
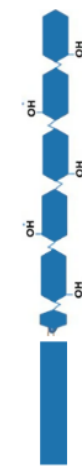
Armrest Substrate  
2014 MKX



Console Substrate 2018  
Continental



Sill Shield  
2020 F150 and F250





# Circularity Through Unlikely Partnerships



JOHN DEERE



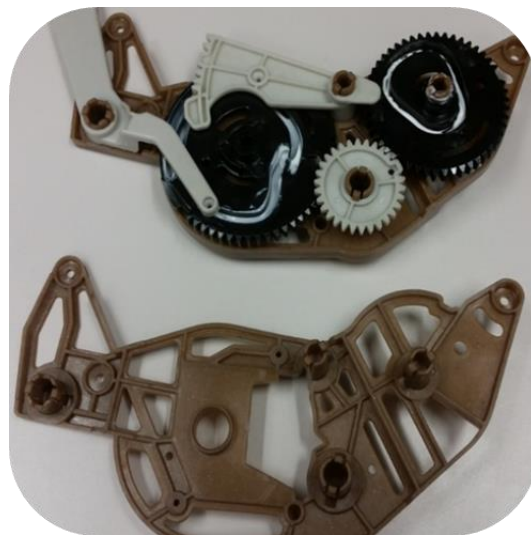
Sustainable Gator



3d waste to wiring clips



Coffee Chaff Headlamps



Agave Fiber to Car Parts



\*from publicly announced partnerships



Plant-PET Ford Fusion



# Morning: Caffeinate Vehicles



McDonald's Coffee Chaff



Coffee chaff processed and turned into black pellets



Straight 'outta McDonald's into cars!



## CAFFEINATE VEHICLES

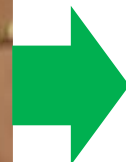
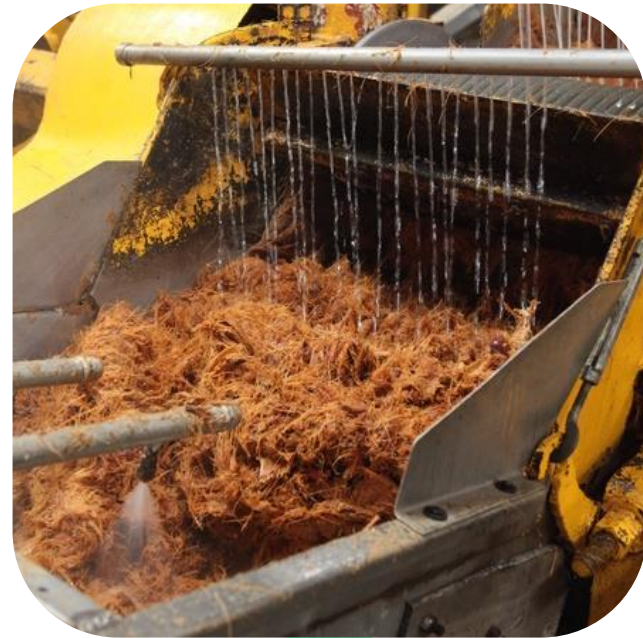


- Similar or better mechanical properties of 40% talc PP.
- Passed heat aging requirements per spec
- Molded parts passed dimensional requirements





# Evening: Build Greener Cars with Agave Fibers





# Ocean Plastic – The Facts



**10M**

tons of plastics ends in our oceans annually. It's a garbage truck load every minute!



**9%**

or less of all plastic get recycled



**50%**

of the 380M tons of plastic produced yearly is for single-use purpose



**40LBS**

is what each human eats in their lifetime



**100%**

of mussels tested contained microplastic



**1M**

of marine animals are killed by plastic pollution every year



**10%**

of ocean plastic is ghost gear



# Circular Driving: Tackling Ocean Ghost Gear



## Process

- Discarded fishing nets are collected by local fishermen from the Indian Ocean and Arabian Sea
- Nets are sorted, cut up, cleaned and extruded
- The product is with and without a GF reinforced recycle-based polyamide 6 (PA6) with excellent functional properties

## What benefits do we see?

- The strength and durability of the PA6 material equals that of the previously used petroleum-based parts.
- 10% cost saving
- Energy saving and LCA benefits
- Improved stability in the supply chain



# HP: 3D Printing Waste Powder into Car Parts



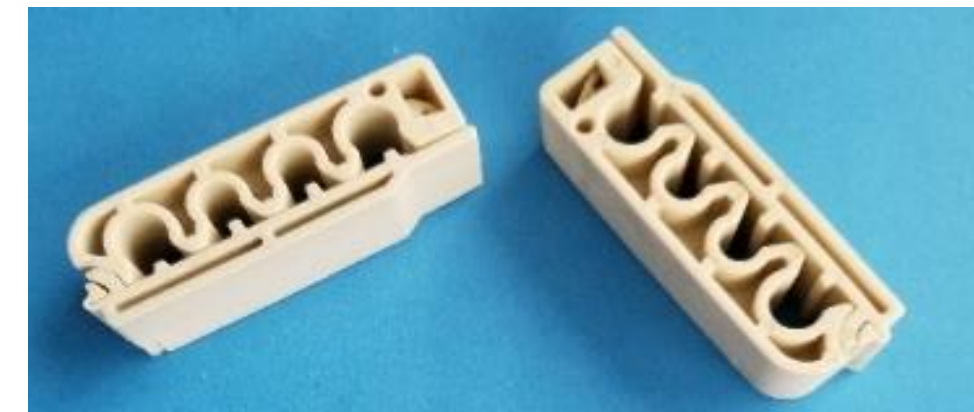
**Powders are sintered layer by layer**



**Left-over powders are removed**



**Left-over powder pelletized**



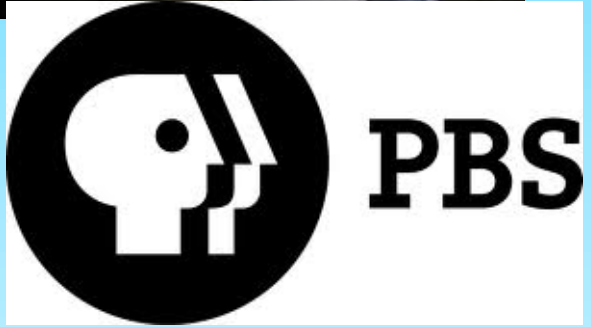
**Final Product**



# Press and Awards

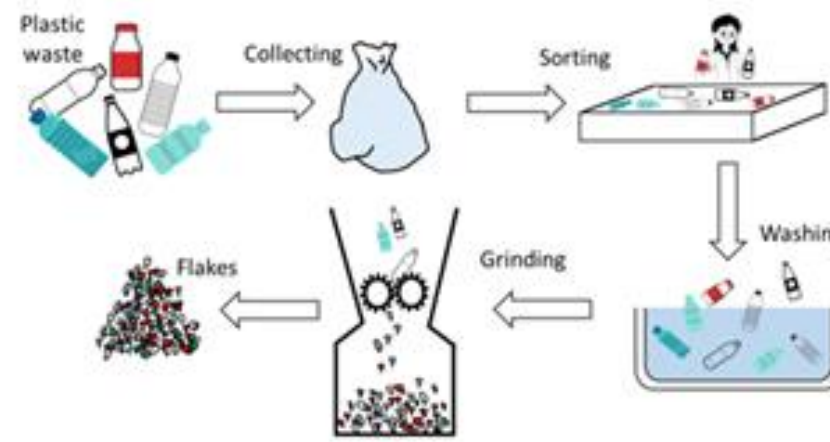


Smithsonian Institution





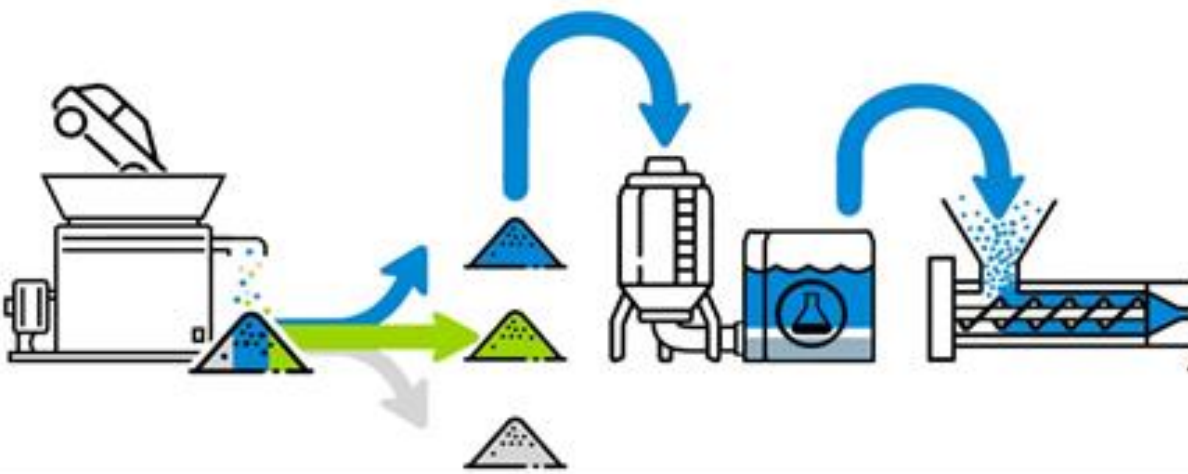
# Transitioning to a Circular Economy and Carbon Neutrality



Now - Mechanical Recycling



Now – Biobased Technologies



Now / Near - Chemical Recycling



Far – CO<sub>2</sub> Recycling

- Increasing PCR/PIR and bio-based content reduces exposure to commodity markets and can insulate from virgin material price fluctuations and shortages



# Blue Skies: Carbon Capture from Manufacturing Plants



Preserving Mother Earth: Ford **First** Automaker To Use Captured CO<sub>2</sub> To Develop Foam And Plastic For Vehicles  
MAY 17, 2016 | DEARBORN, MICH./FORBES



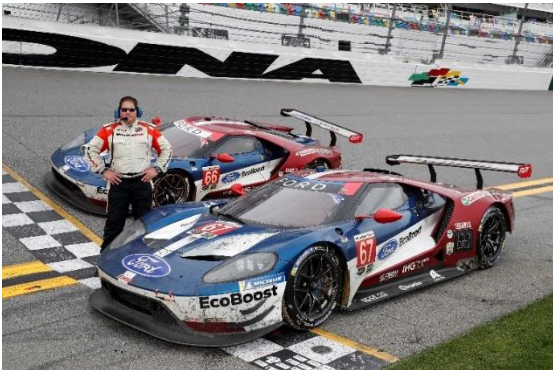
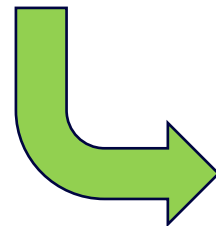
INFINIUM IS WORKING WITH PARTNERS WHOSE CO<sub>2</sub> WILL BE BENEFICIALLY RECYCLED INSTEAD OF RELEASED INTO THE ATMOSPHERE.

Infinium reactor using the proprietary CO<sub>2</sub>Cat™ catalyst

Products are net-zero carbon fuels and building blocks for polymers



50-70 pounds of urethane foam  
PET: fabric, carpet, headliner, underbody shield, wheel liners



e-fuel powers racing!



# More Sustainable Polyurethanes?

- Could address already landfilled material
- Process is similar to that already used in plastics industry

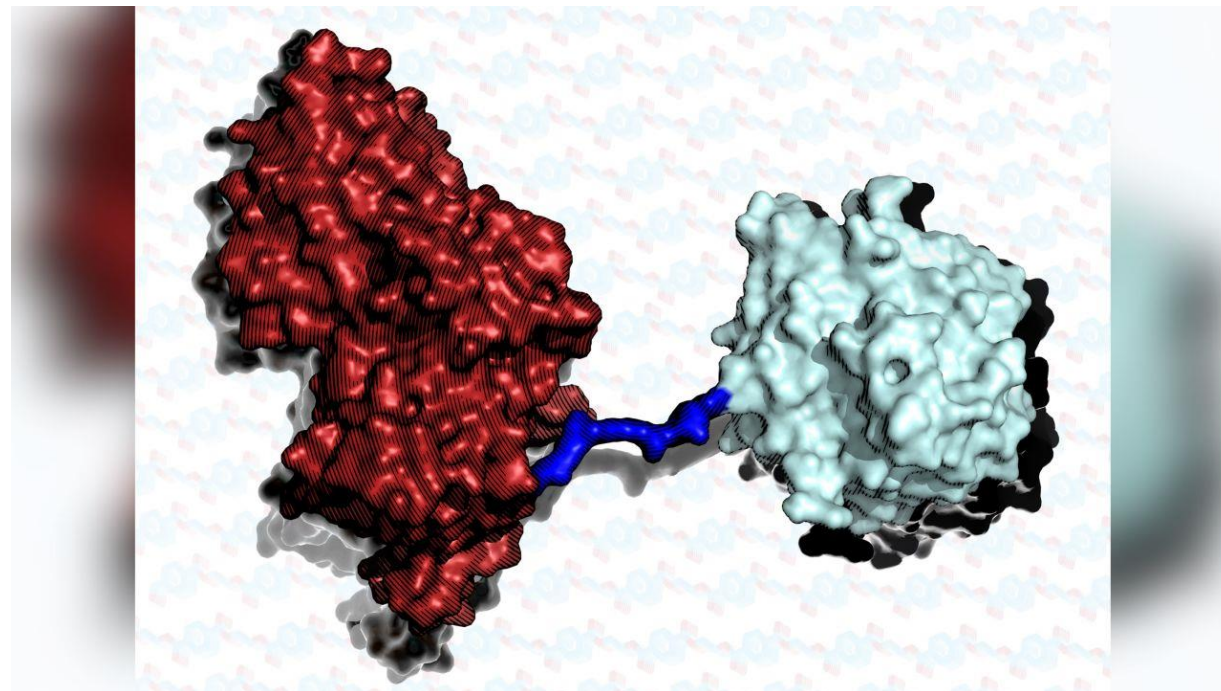


*Credit: Sheppard et al., ACS Central Science*



# Or Are Enzymes and *Bugs* the Answer?

PETase was discovered by Japanese scientists in 2016



From U Portsmouth website

Combination of  
PETase with a  
Second enzyme  
speeds up  
decomposition

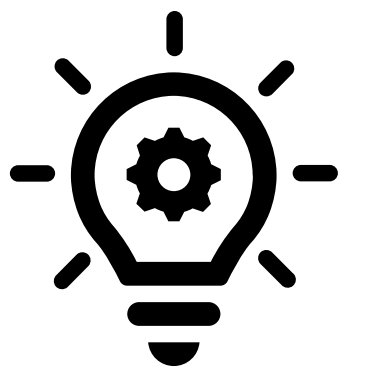
FAST-PETase (functional, active, stable, and tolerant) was shown to decompose 51 post-consumer plastic containers, five different polyester fibers and fabrics and water bottles, all from PET



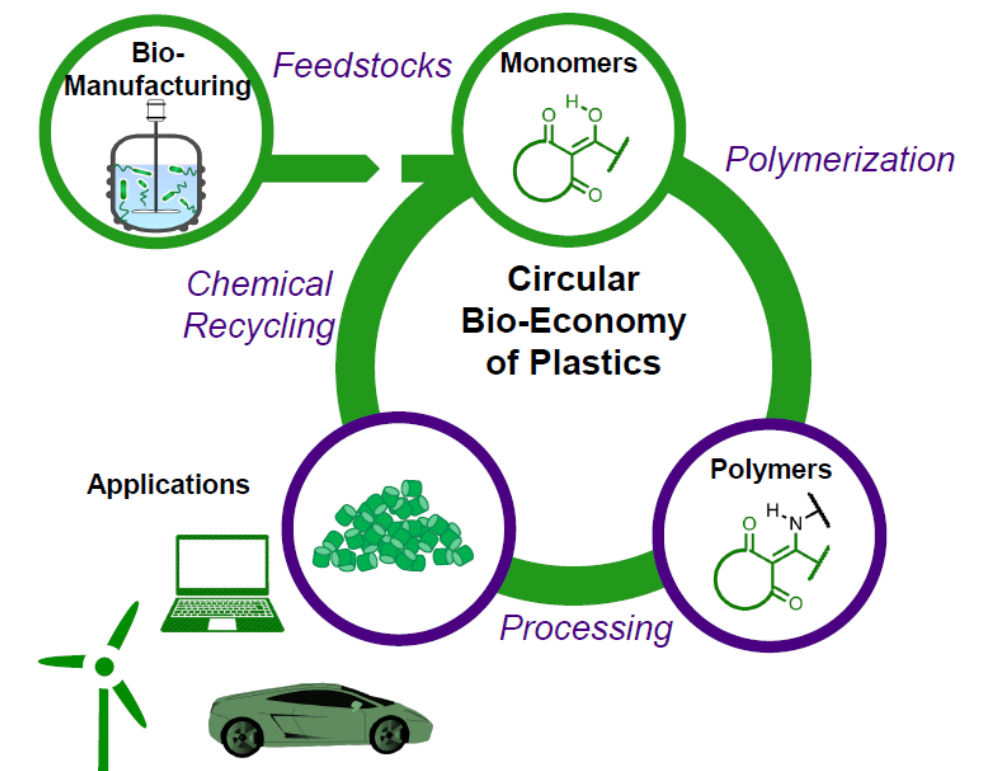
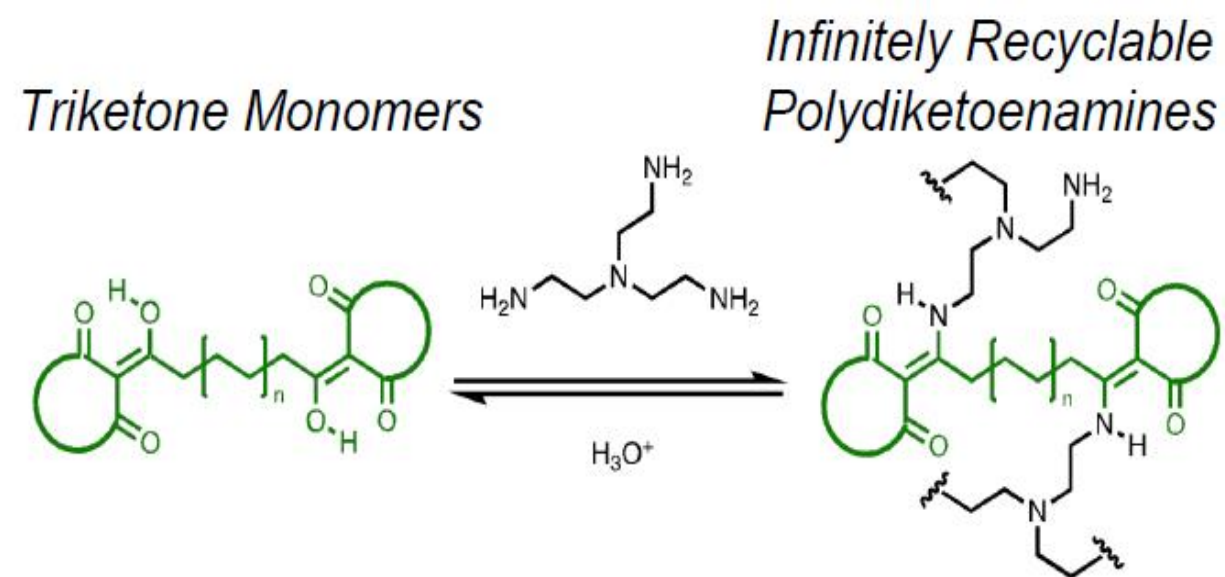
Waxworm caterpillars can live on a diet of plastic bags



# Big Ideas - New Ways to Think About Recycling



- UC Berkeley and Lawrence Berkeley National Lab invent infinitely recyclable polymers from bio-based 1,3-diketones converted to polydiketoenamine resins (PDK)
- Varying configurations “click” together to form a wide variety of materials with varying properties
- Designed to be completely recyclable, non-toxic with monomer recovery using ambient acid/water
- Orders of magnitude lower GHG emissions



Imagine if all plastics could be assembled from common blocks and at end of life infinitely transformed into new materials!



# Electric Vehicles Have Arrived—What Will Happen Next?





# Efficient Battery Recycling/Recovery Will Be Critical for Sustainability!



1,500T of ore are mined to get 1T of cobalt

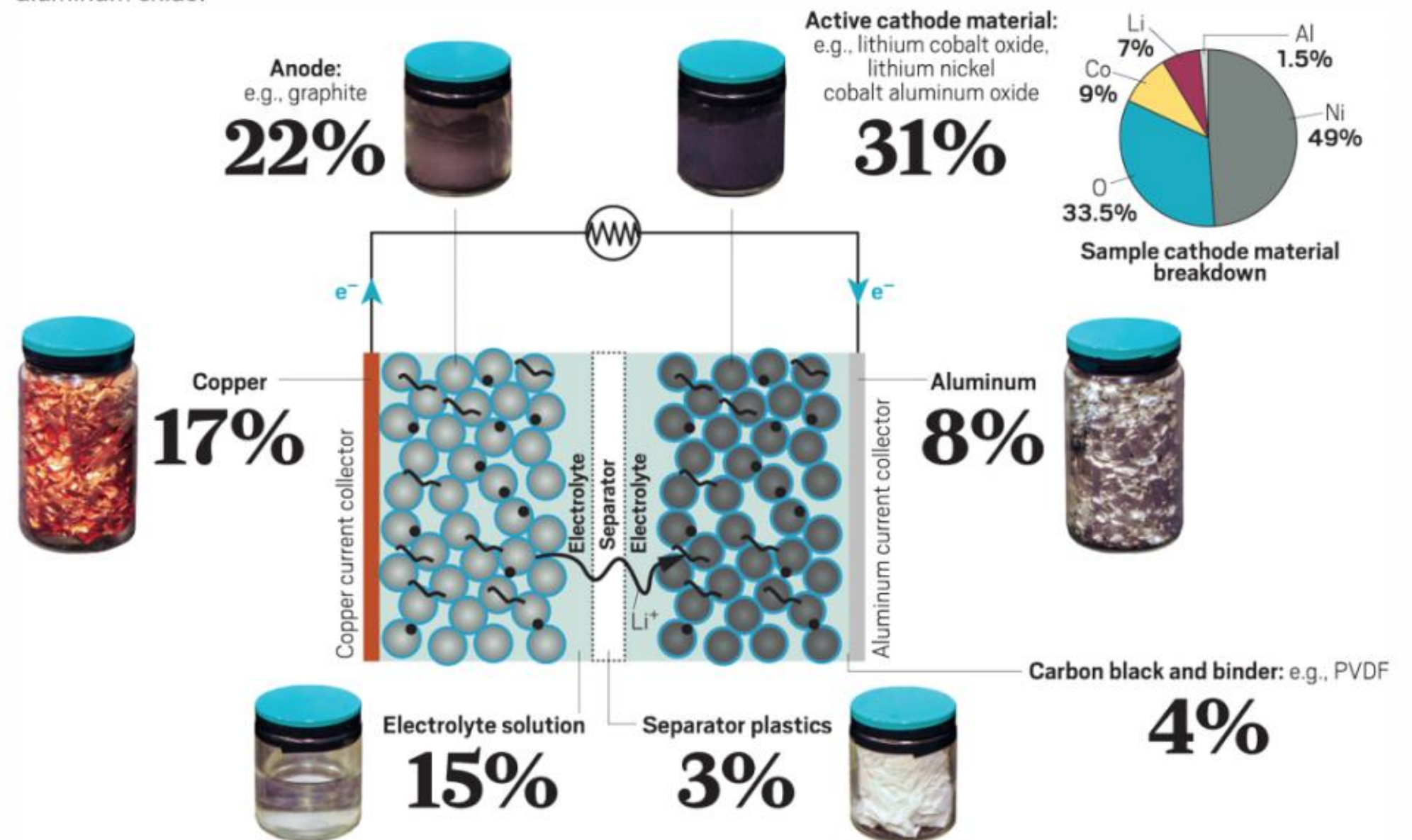


0.5M gal of H<sub>2</sub>O used per ton of lithium

Photo source: Wikimedia

## Inside a Lithium-Ion Battery

All the components of a Li-ion battery have value and can be recovered and reused. Currently, most recyclers recover just the metals. The pie chart describes a cathode material known as NCA, which is made of lithium nickel cobalt aluminum oxide.

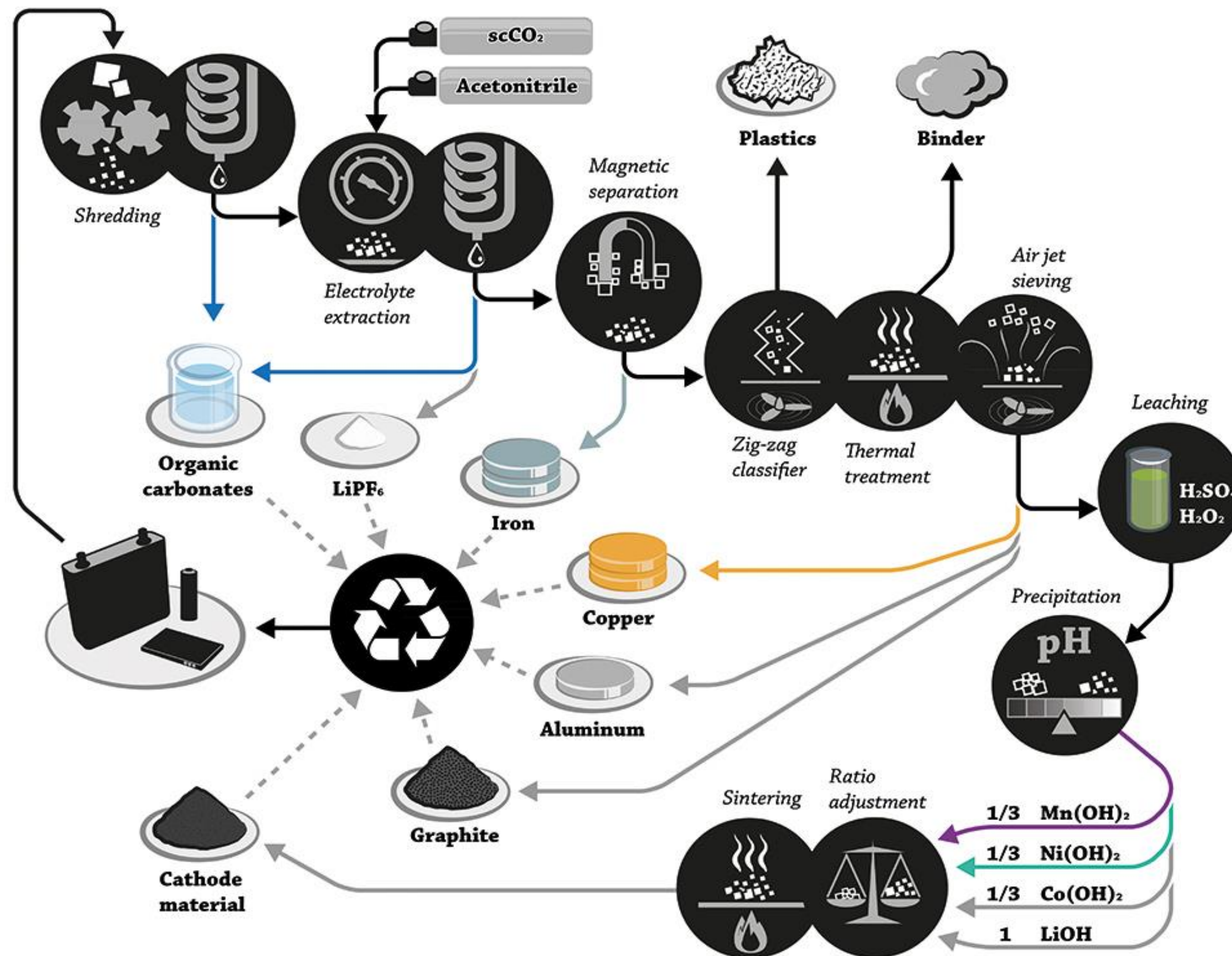


Credit: Mitch Jacoby/C&EN

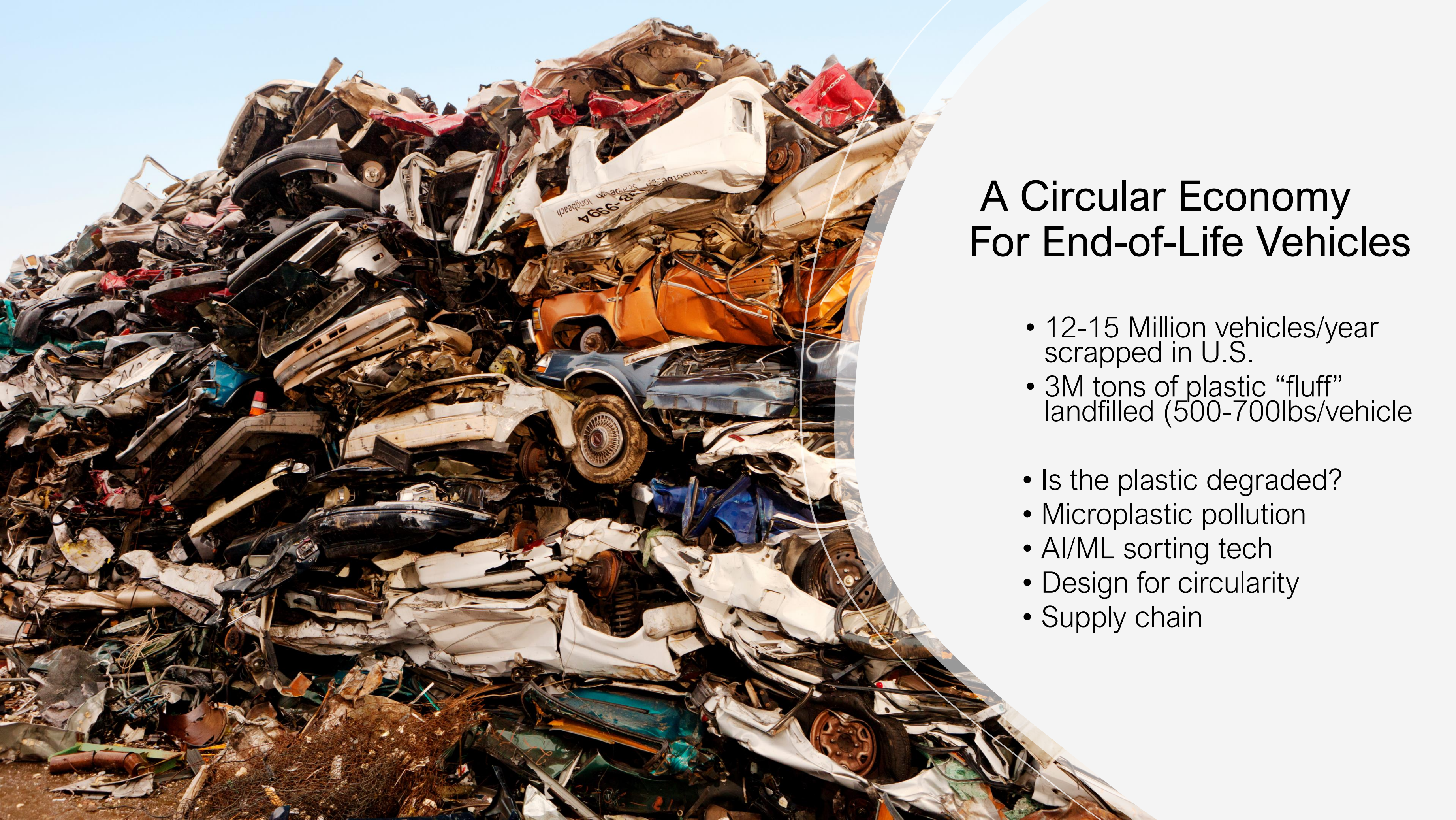
Source: Argonne National Laboratory.



# Battery Recycling: Toward a Circular Economy







## A Circular Economy For End-of-Life Vehicles

- 12-15 Million vehicles/year scrapped in U.S.
- 3M tons of plastic “fluff” landfilled (500-700lbs/vehicle)
- Is the plastic degraded?
- Microplastic pollution
- AI/ML sorting tech
- Design for circularity
- Supply chain



# A Call to Action

- Just because we do something one way, doesn't mean we can't do it better
- Push your companies to act & provide resources
- Be innovative—think big, outside the box
- Use data to manage risk
- Small changes can make an impact, don't let size get in the way of progress
- Set an example of what CAN be done for others—inspire them
- Don't entrust the health of the planet to the very same actors that have destroyed it
- Bring available environmental technologies to market!





# What kind of footprint do we want to leave behind?



**BIRDS**



**TURTLES**



**HUMANS**



**DESIRED**