U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

ADVANCED MATERIALS &
MANUFACTURING
TECHNOLOGIES OFFICE

AMMTO Sustainable Materials Portfolio Overview

September 24, 2024

Ally Robinson Turner

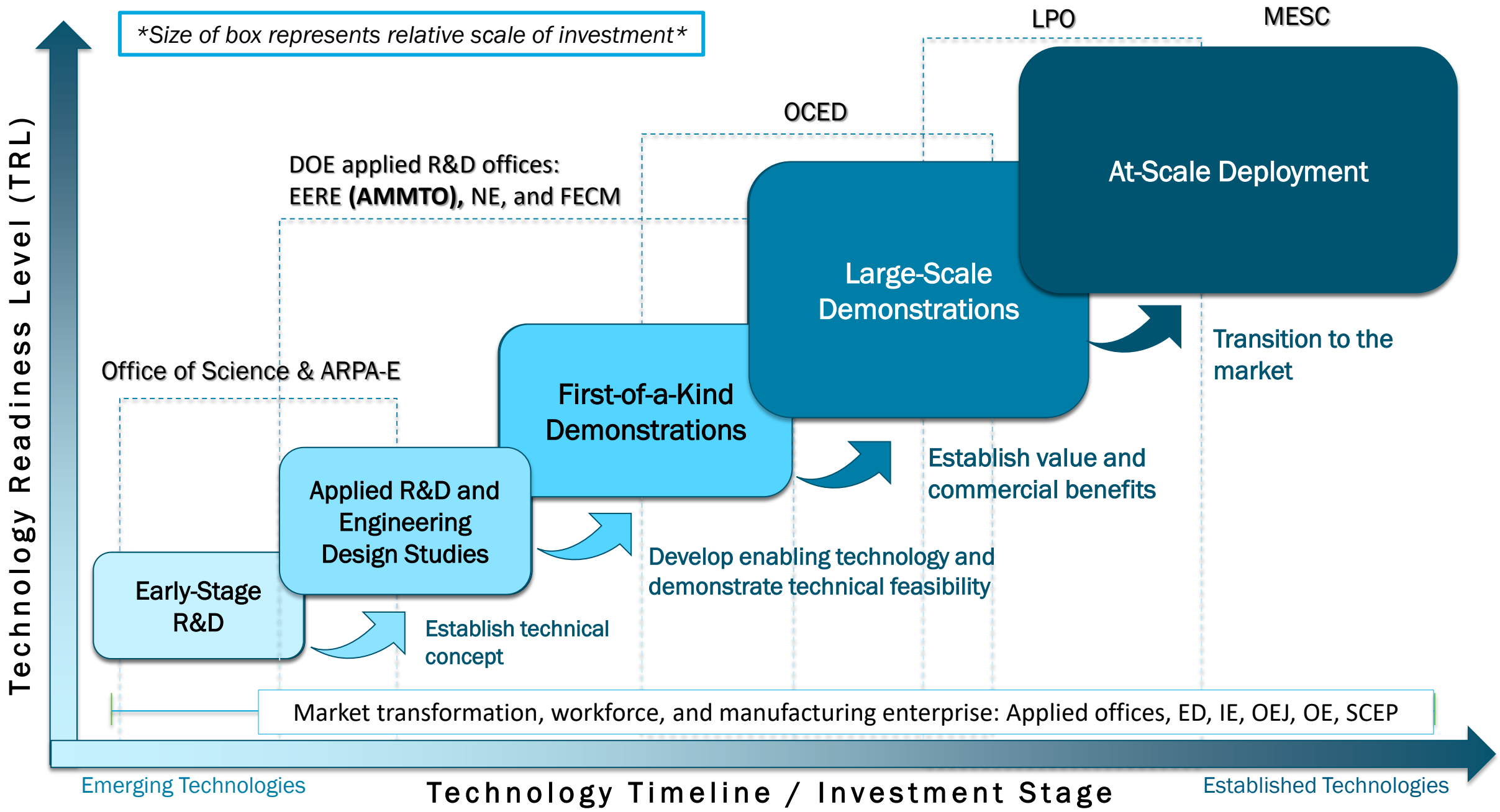
What is AMMTO All About?

Vision

A globally competitive U.S. manufacturing sector that accelerates the adoption of innovative materials and manufacturing technologies in support of a clean, decarbonized economy.

Mission

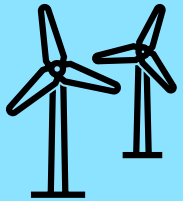
We inspire people and drive innovation to transform materials and manufacturing for America's energy future.


Size of box represents relative scale of investment
LPO
MESC
OCED
DOE applied R&D offices:
EERE (AMMTO), NE, and FECM
Office of Science & ARPA-E
At-Scale Deployment
Large-Scale Demonstrations
First-of-a-Kind Demonstrations
Applied R&D and Engineering Design Studies
Early-Stage R&D
Transition to the market
Establish value and commercial benefits
Develop enabling technology and demonstrate technical feasibility
Establish technical concept
Market transformation, workforce, and manufacturing enterprise: Applied offices, ED, IE, OEJ, OE, SCEP
Technology Readiness Level (TRL)
Emerging Technologies
Technology Timeline / Investment Stage
Established Technologies

AMMTO's Subprogram Structure

NEXT-GENERATION MATERIALS & PROCESSES

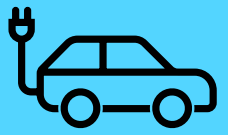
Advanced Manufacturing Processes and Systems



High Performance Materials

SECURE & SUSTAINABLE MATERIALS

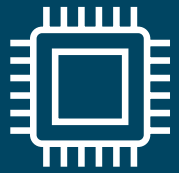
Circular Economy Technologies and Systems



Critical Materials

ENERGY TECHNOLOGY MANUFACTURING & WORKFORCE

Energy Conversion and Storage Manufacturing



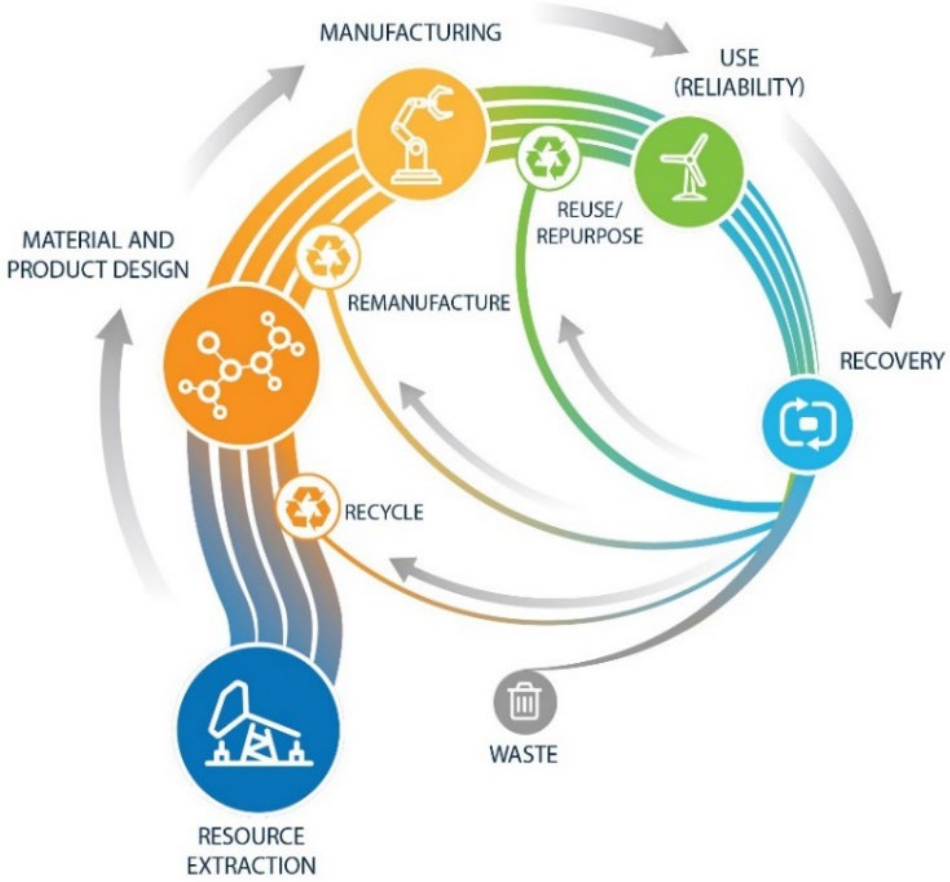
Semiconductors, Electronics, and Other Technologies Manufacturing

Entrepreneurial Ecosystems and Advanced Mfg. Workforce

Circular Economy: Mission and Context

A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life.

- **Economy-wide Decarbonization**
  - Circular economy strategies and technologies enable economy-wide decarbonization through material efficiency, which reduces the demand of extracted materials.
- **Supply Chain Innovations**
  - Circular economy approaches, particularly when applied to limited elements needed for clean energy technologies, can help secure domestic supply chains.
- **Manufacturing Competitiveness**
  - With requirements for recycled content and taxes on virgin materials being discussed, cost-effective circular economy solutions will be needed to remain competitive.

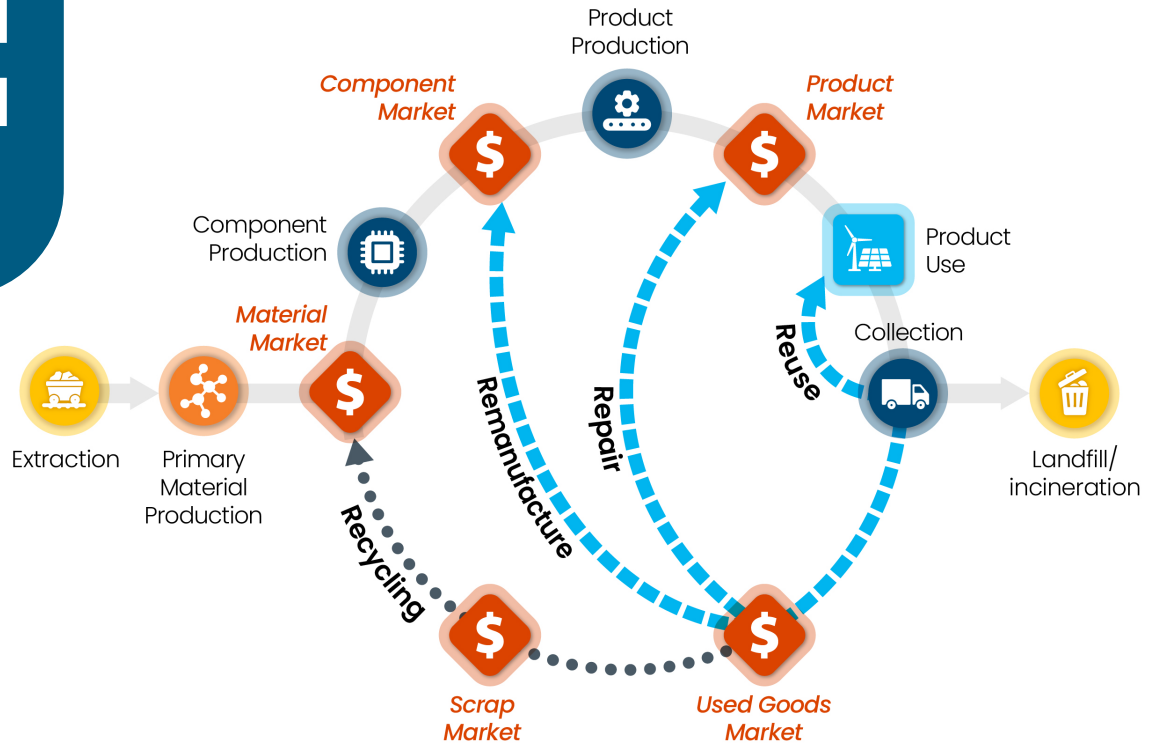


NREL, Circular Economy Model (2022)

Markets are a Key Aspect of the Circular Economy Model

Product and material circularity aims to minimize life cycle impacts though increasing recirculation of products and materials in the economy. This model only works if there are the required markets in place.

Current “linear economy” model

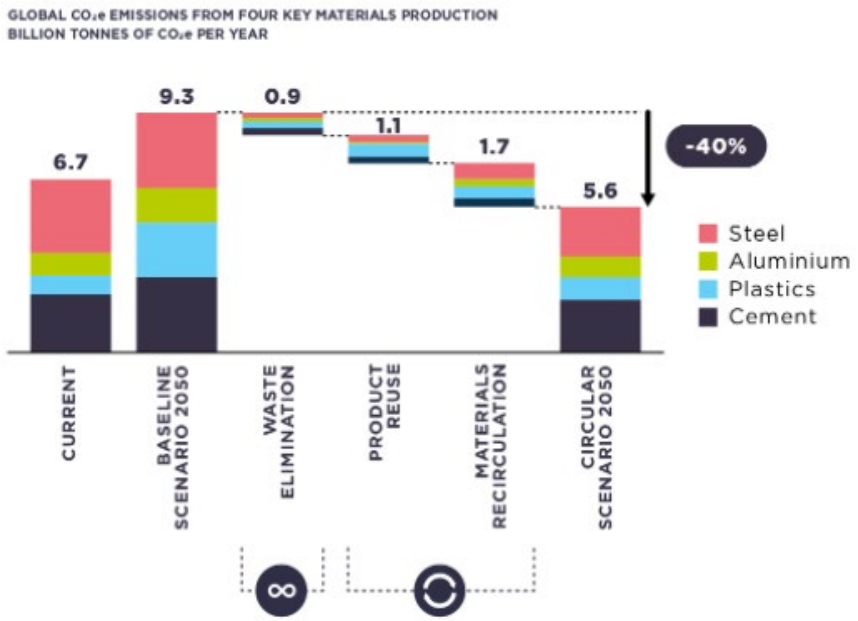


“Circular economy” model

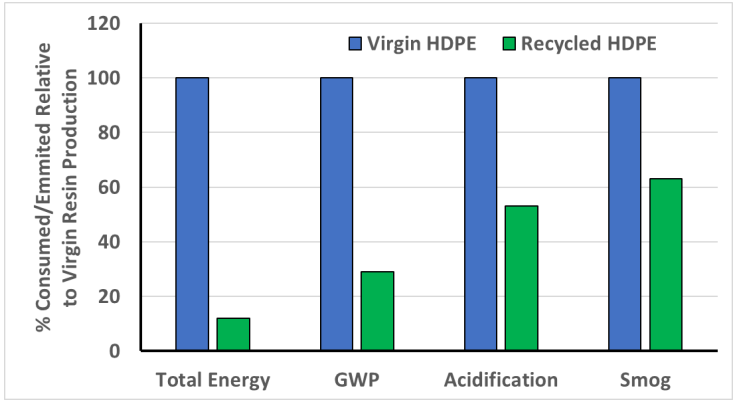
Circularity has a Unique Opportunity to Impact Energy, the Environment, and Equity in the Near Term

A circular economy reduces material use, redesigns materials, products, and services to be less resource intensive, and recaptures "waste" as a resource to manufacture new materials and products.

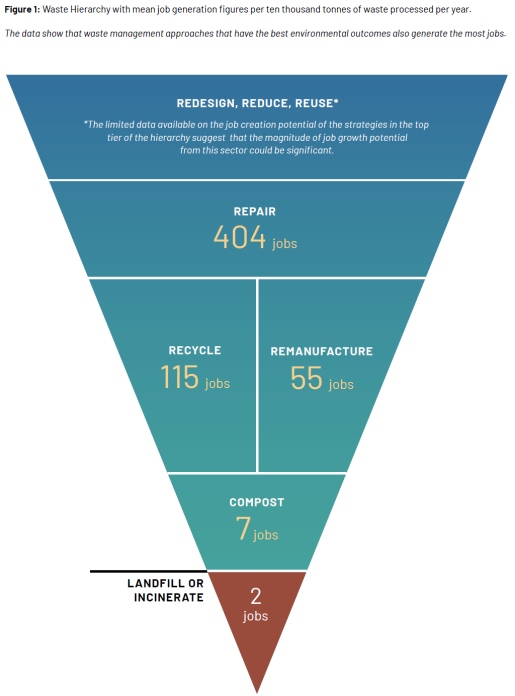
Circular economy strategies have the potential to reduce global emissions by over 40% by 2050.



Benefits from circular approaches often extend beyond emissions and include energy savings and other indicators of human and environmental health.



Shifting to a circular economy can generate economic growth and jobs.



1. Nicholson *et al*. *Joule* 2021, 5, 1–14 2. Kimmel *et al*. *Environmental Studies* 2014, 6. 3. Trenor *et al. ACS Macro Lett*. 2020, 9, 1376−1390 4. Virgin vs Recycled Plastic LCA White Paper APR 2020. 5. Ellen MacArthur Foundation, Completing the Picture: How the Circular Economy Tackles Climate Change (2021).

History of the Program

2015 QTR

Highlighted material efficiency as an important mechanism to reduce energy and emissions.

2017 – REMADE Est.

2019 – Plastics Innovation Challenge Launched

Li-ion Battery Prize Announced

2020 – BOTTLE Consortium Est.

BOTTLE FOA

2021 – SUPR FOA

2022 – Circular Economy Regional Demos Topic

2023 – Strategy for Plastic Innovation

and

"Sustainable Manufacturing and the Circular Economy" Published

REMADE INSTITUTE

AMERICAN MADE BATTERY RECYCLING PRIZE
U.S. DEPARTMENT OF ENERGY

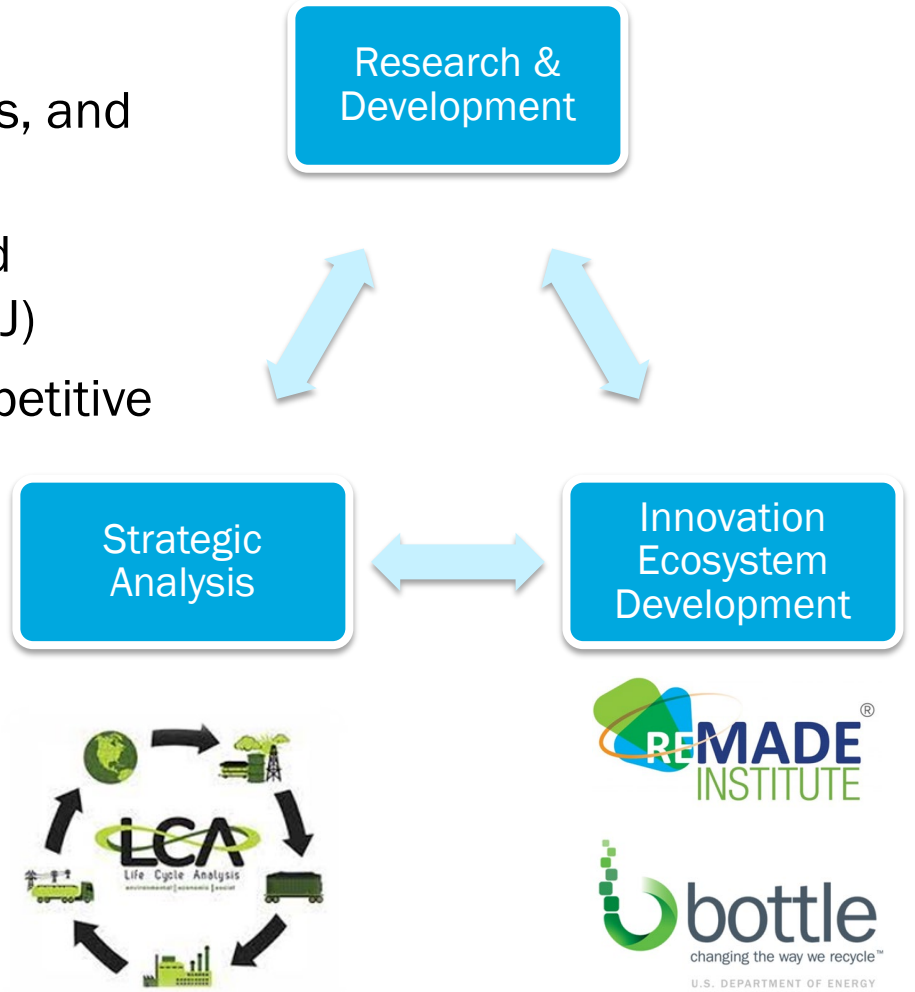
bottle
changing the way we recycle™
U.S. DEPARTMENT OF ENERGY

Circular Economy Scope and Priorities

Invest in cross-cutting innovations that promote material circularity to:

- Minimize lifecycle impacts, including energy, emissions, and waste
- Promote energy, equity and environmental justice (EEEJ)
- Remain economically competitive

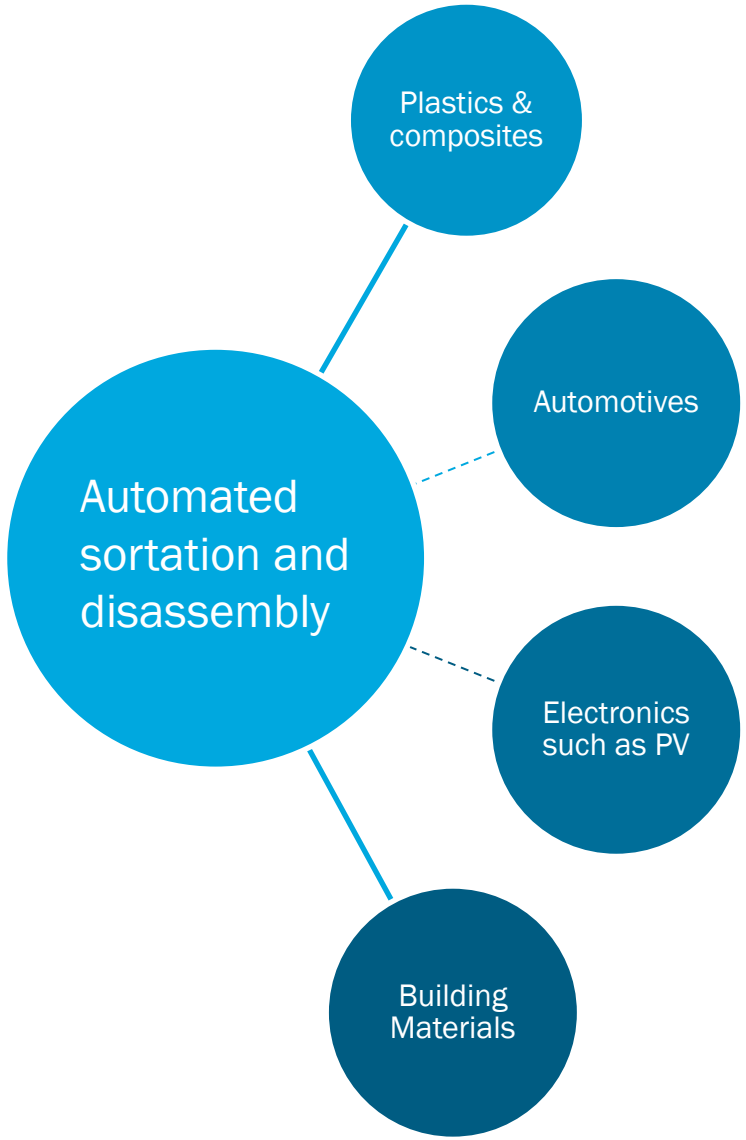
Develop and leverage analysis and LCA capabilities for better decision making.



Convene the full supply chain and accelerate technology development by creating or cultivating innovation ecosystems.

Leverage previous investments in Strategy for Plastic Innovation, BOTTLE™ consortium, and REMADE Institute.

AMMTO's Role in Developing Platform Technologies for Circularity



One of AMMTO's focuses in circularity is to develop platform technologies that can be applied to a variety of materials and products. These include:

- Design for Re-X tools/methodologies
- Advanced sortation and the required sensing and analytics needed
- Supply chain alignment
- Lifecycle analysis data, tools, and capability development

One example of AMMTO's crosscutting efforts is the REMADE Institute – Address Circularity Broadly

REMADE MISSION: Reduce embodied energy and carbon emissions through early-stage applied research & development

- Systems Analysis & Integration
- Design for Re-X
- Manufacturing Materials Optimization
- Remanufacturing & EOL Reuse
- Recycling & Recovery

MATERIAL CLASSES

Metals

Polymers/Plastics

E-Waste

Fibers

 Funding provided by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under Advanced Manufacturing Office Award Number DE-EE0007897.

Example of one of REMADE's Projects in Food Packaging

Recycling of PET in Sustainable Food Packaging Systems

- **Food packaging containers account for 30% of waste generation in the U.S., and less than 50% of this volume is currently recycled.** That recycling rate is even less for the types of multilayer food packaging targeted in this project, including the brick-shaped cartons commonly used for milk, juices, soups, sauces, and more.
- The project team developed a process by which these multilayer materials can be replaced by a single mono-material packaging solution produced from up to **100% recycled PET** (the same plastic that water bottles are made from) that can be recycled back into the same or comparable products with minimal reprocessing, handling, and transportation.
- The team is **validating the performance** of the materials and manufacturing process at industrial scale and is conducting a recycling pilot with the support of a MRF to quantify recycling rates and recycled material quality. Implementation is planned through the Ohio Safe Food & Packaging Initiative.

THE OHIO STATE UNIVERSITY

CIFT

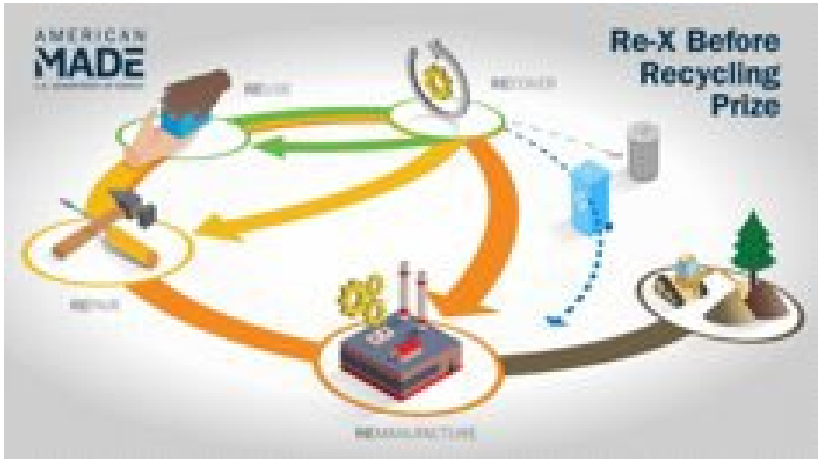
WINGATE PACKAGING
BRANDWORTHY PACKAGING SOLUTIONS

plastilene
Soluciones de pelicula

SugarCreek
Brandworthy Food Solutions
Since 1966

Future Opportunities: Diversifying Re-X Approaches

- Current portfolio is weighted towards recycling pathways, particularly for plastics.
- Going forward, we want to continue to assess and address the lifecycle impacts of and technology development needs of Re-X pathways.
    - Re-X Before Recycling Prize expands beyond recycling. **Phase II applications are open through October 22!**



Circular Economy

Increasing Circularity

Linear Economy

	Strategy	Description
Smarter product use and manufacture	**R0** - Refuse	Making products redundant by abandoning their function or by offering the same function with a radically different product
	R1 - Rethink	Make product use more intensive
	R2 - Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
Extend lifespan of products and their parts	**R3** - Re-use	Re-use by another consumer of discarded product which is still in good condition and fulfills its original function
	R4 - Repair	Repair and maintenance of defective product so it can be used for its original function
	R5 - Refurbish	Restore an old product and bring it up to date
	R6 - Remanufacture	Use parts of discarded products in a new product with the same function
	R7 - Repurpose	Use discarded products or their parts in a new product with a different function
Useful application of materials	**R8** - Recycle	Process materials to a commodity level with same or lower quality
	R9 - Recover	Incineration of materials with energy recovery

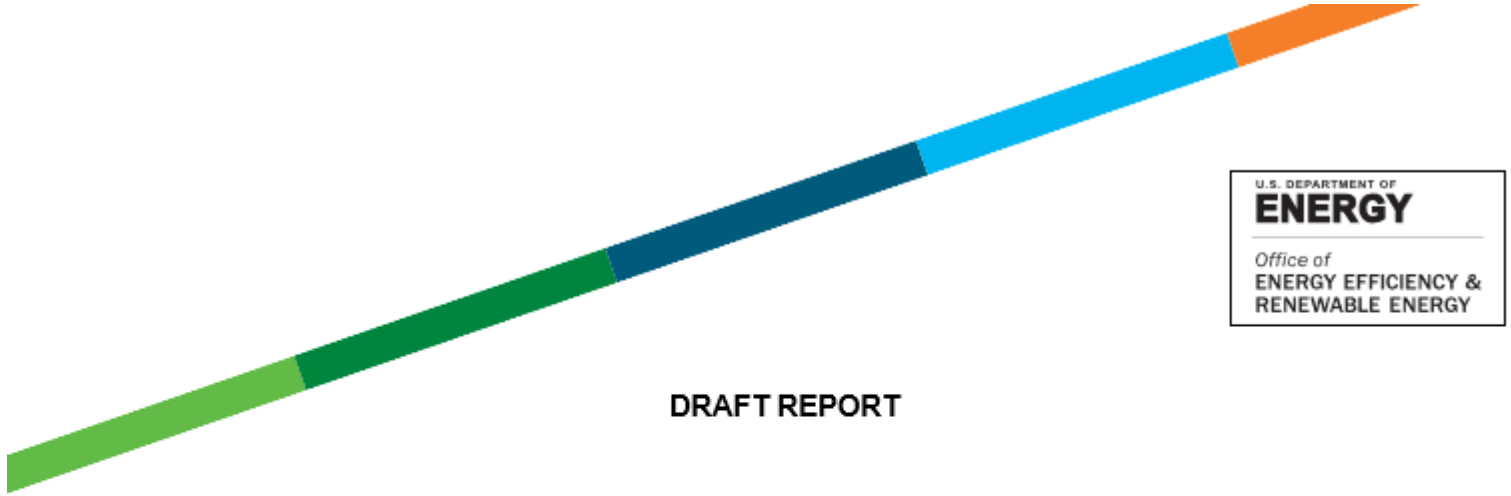
Figure ES 2. Circular economy strategies (collectively Re-X) with descriptions and circularity ranking

After Potting et al. (2017), which is based on RIi (2015).

Sustainable Manufacturing and the Circular Economy, DOE (2023).

EERE Document on Product and Material Circularity Coming Soon

A draft document with an RFI will be released soon – please provide your feedback through the RFI!



Join AMMTO's Newsletter to get updates on the RFI release!

https://www.energy.gov/eere/ammto/ammto-news-and-events

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Join our Reviewer Panel for Future Funding Opportunities!

- **Help shape the future by reviewing proposals for cutting-edge, innovative projects and technologies.**
- **Contribute to diversity and inclusion in the reviewer process, ensuring varied perspectives.**
- **Make an impact by helping select innovative and transformative projects for funding.**
- **Expand your professional network by collaborating with peers in your area of expertise.**
- **We're seeking subject matter experts with at least 1-3 years of relevant professional experience.**

If interested, please reach out to eere_ammto@ee.doe.gov and we'll get back to you!

- Diversity, equity, inclusion, and accessibility (DEIA)
- Community and regional planning
- Chemical engineering
- Process engineering
- Process scale-up
- Chemical production
- Chemistry
- Mechanical engineering
- Green design and manufacturing
- Materials science
- Electrical engineering
- Physics
- Condensed matter physics
- Electro-magnetism
- Device design and fabrication
- Semiconductor processing
- Electro-chemistry
- Waste management
- Environmental/natural resource science
- Renewable energy technologies
- Critical materials
- Circular economy
- Resource management
- Sustainability

Questions?