Advanced Manufacturing Office Overview

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Advanced Manufacturing Office

Advanced Manufacturing Office (AMO)

AMO is dedicated to improving energy efficiency and reducing carbon emissions of the industrial sector while delivering innovations to drive manufacturing of next generation energy technologies.

Industrial Efficiency and Decarbonization

- Reducing Greenhouse Gas Emissions from industries through new manufacturing technologies

Clean Energy Manufacturing

- Solving key manufacturing challenges for clean energy technologies that are critical for achieving economy-wide decarbonization

Material Supply Chains

- Developing secure and sustainable supply chains and high-performance materials

Technical Assistance and Workforce Development

- Providing technical assistance and developing the manufacturing workforce of the future

BUDGET

$416M

FY22

Guiding Principles for AMO

AMO invests in manufacturing innovation
to accelerate and strengthen the clean economy for all.

MANUFACTURING

- Uses roughly 33% of the nation's primary energy
- Accounts for almost one-third of the U.S.'s greenhouse gas emissions
- Represents nearly 80% of energy use in energy-intensive sectors
- Generates 12% of the U.S. GDP and 12.5 million jobs
- Incurs $150 billion in energy costs annually

KEY AMO GOALS

Decarbonize the industrial sector

- *Enable net zero non-energy and energy-use emissions*

Manufacture clean energy technologies domestically

- *Lead the world in clean energy technology manufacturing*
- *Drive innovation that advances the clean energy economy*

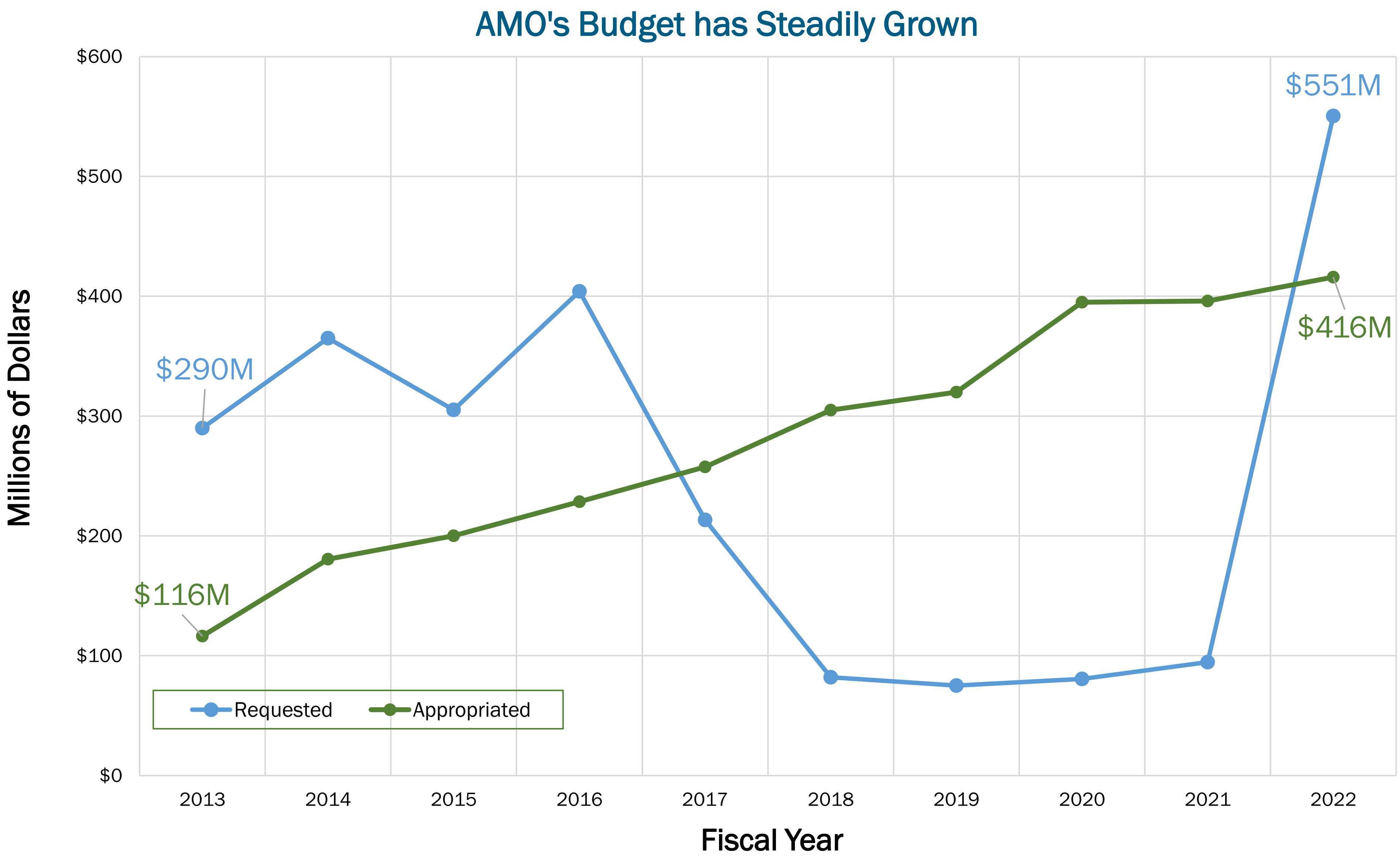
Develop secure and sustainable supply chains

- *Support resilient supply chains for critical materials*
- *Enable recycling and a circular economy*

Support a skilled and inclusive manufacturing workforce

- *Ensure fair access to employment, prioritize training for workers in underserved communities*
- *Position the manufacturing workforce as a model of diversity*

Continuing Bipartisan Support for AMO



Year	FTE Count
FY13	33
FY14	32
FY15	31
FY16	36
FY17	34
FY18	33
FY19	32
FY20	48
FY21	48
FY22	54 (59 including BIL)

Energy and Environmental Justice and DEIB at AMO

Supporting *Energy and Environmental Justice* through the Biden Administration's *Justice40 Initiative*

- *Working to deliver 40% of the overall benefits of relevant federal investments to disadvantaged communities.*

Embracing *Diversity, Equity, Inclusion, and Belonging (DEIB)* throughout AMO programs:

- *Recognizing diversity and inclusivity in the AMO and manufacturing workforce, and as a source of strength in science and technology partnerships*

Partnering across DOE to develop and expand workforce training initiatives to underserved communities

- *Increasing outreach, access to, and diversity of participation in training and education programs.*

Through prioritization of Justice40, DEIB, and Energy Justice initiatives, AMO programs support EERE's core areas of emphasis:

- *STEM research and Entrepreneurship*
- *Workforce Development*
- *State & Local*
- *Energy Equity and Environmental Justice*

Industry Contributes Significantly to CO_2 Emissions

THE U.S. INDUSTRIAL SECTOR

manufacturing | agriculture | mining | construction

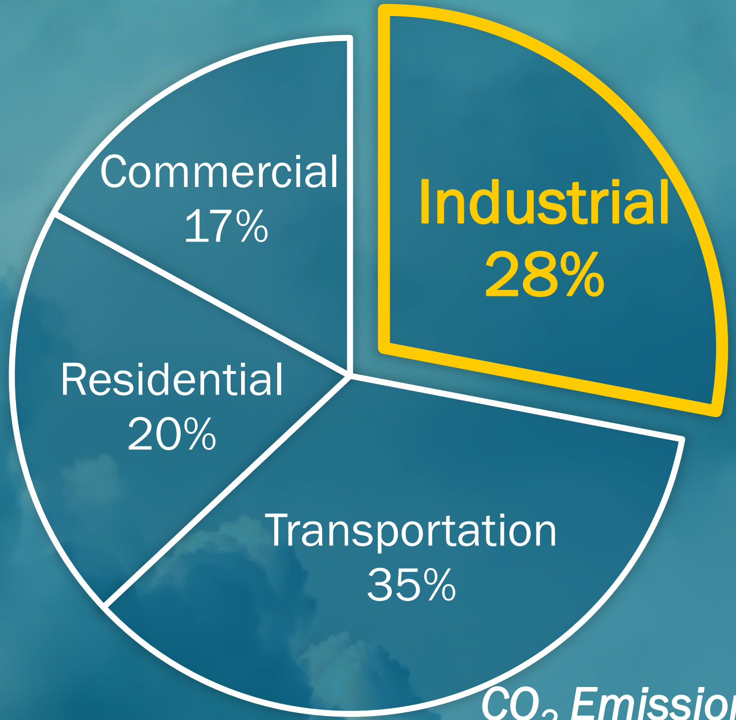
ACCOUNTS FOR

32% of the nation's primary energy use

28% of CO_2 emissions

Anticipated industrial sector energy demand growth of 30% by 2050 may result in a

15% CO_2 emissions increase



CO_2 Emissions By Sector

Technological advances in manufacturing will be critical to enabling decarbonization for other sectors.

Decarbonizing the industrial sector is key to addressing the climate crisis and achieving economy-wide, net-zero emissions by 2050.

EIA, *Annual Energy Outlook 2020 with Projections to 2050.*

Clean Energy Manufacturing Example: Flow Batteries

AMO focuses on issues of domestic supply chain and manufacturing. Collaboration is key to success.

Key Actions Towards Flow Battery Technology Advances

Upstream → Midstream → Downstream

Upstream	Midstream			Downstream	
Raw material extraction	Materials processing	Component manufacture	Product assembly	Product use phase	End of life

- Cell stack → Bipolar plate; Electrode; Membrane; Cell frame; Accessories
- Electrolyte storage → Electrolyte; Tank
- Balance of plant → Recirculation loops (pipe and pump); Battery management system (processing control, temperature control, balance cell and monitor); Power conditioning system (Invertor); Accessories

AMO

- Strengthening flow battery supply chains
- Domestic flow battery systems' manufacturing capabilities
- Optimized flow battery component design and manufacturing for scale-up
- System assembly processes for subsystems

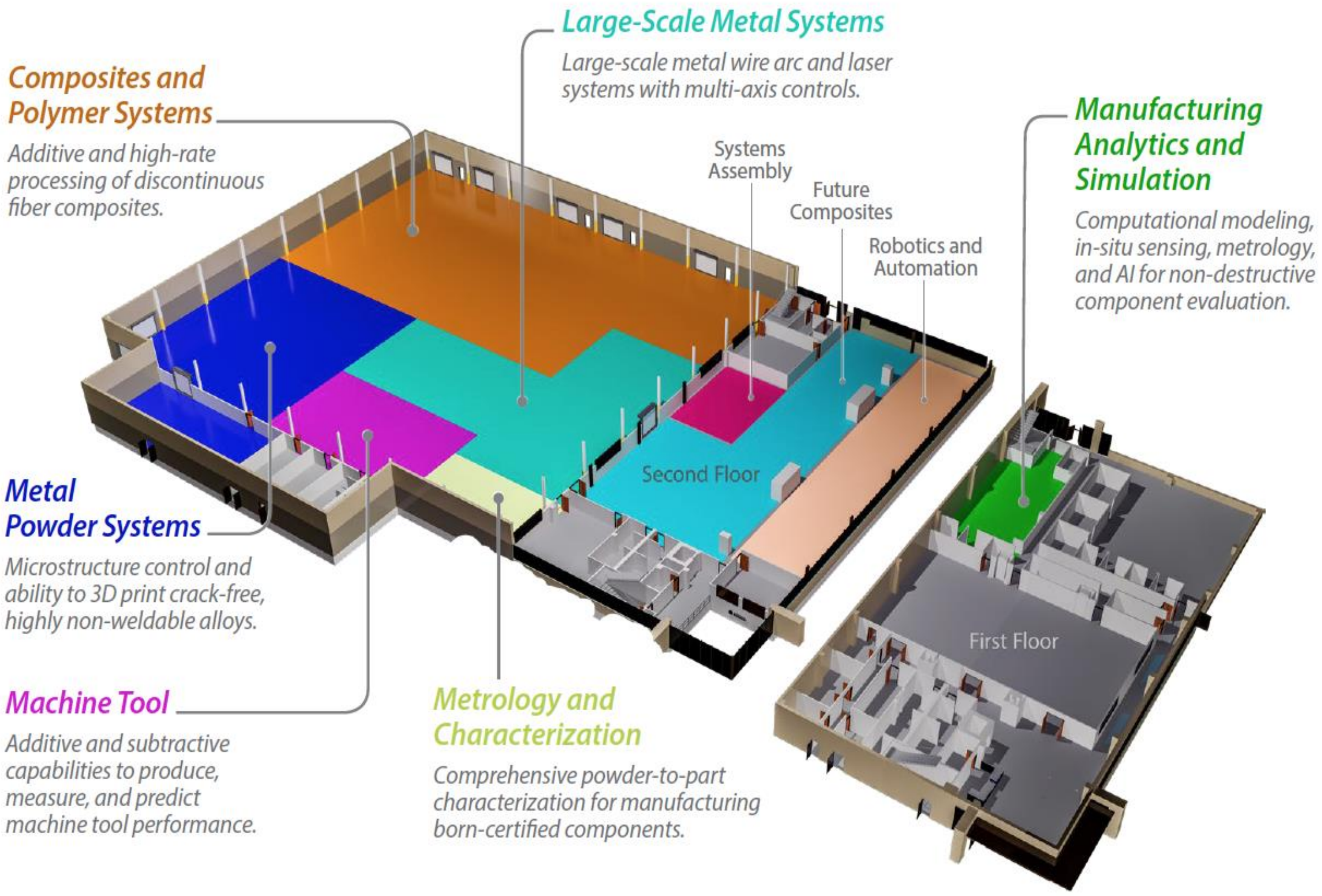
OE

- Development of safe and reliable energy storage systems in large-scale deployment
- Developing a scientifically derived knowledge base to improve the understanding and predictability of energy storage systems and components
- Grid use cases and testing protocols

Manufacturing Demonstration Facility

Open-door, manufacturing-focused user facility at Oak Ridge National Laboratory

- Facilitates adoption of advanced manufacturing technologies that improve energy and material efficiency, productivity, and competitiveness
- Provides industry with affordable and convenient access to infrastructure, tools, and expertise



CAPABILITIES

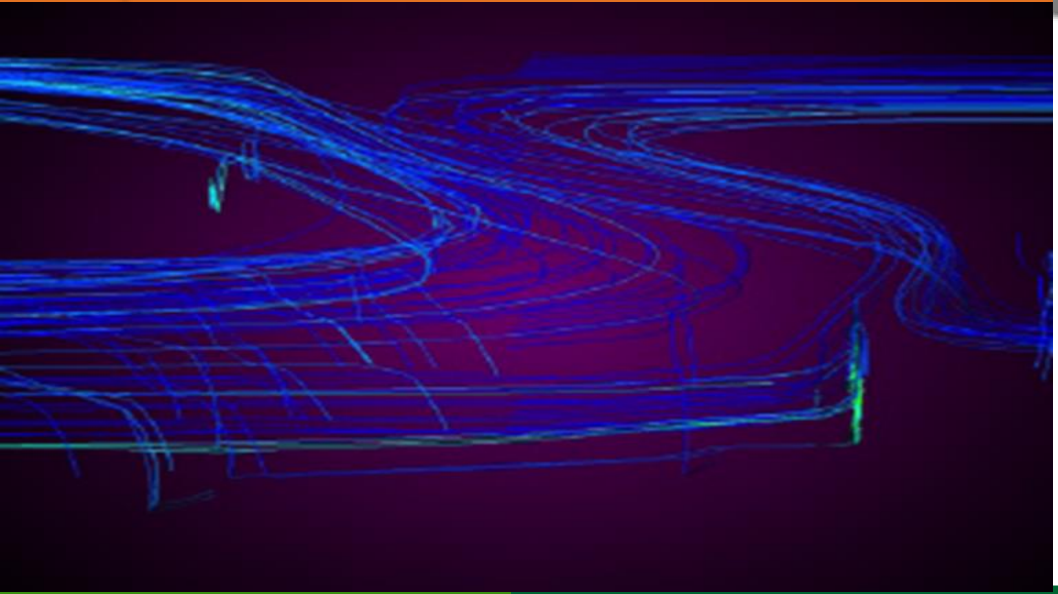
- Additive and subtractive manufacturing
- Advanced materials
- Composites recycling and recovery
- Controls and analysis
- Automation
- Modeling and characterization
- Systems development

High Performance Computing (HPC)

CAPABILITY

HPC expedites the development of energy-efficient manufacturing processes across U.S. industry—boosting competitiveness and global leadership.

- HPC-developed machine-learning tools enable manufacturers to make real-time process adjustments instead of taking machinery offline.
- HPC tools can improve energy and material productivity by harnessing large amounts of data.



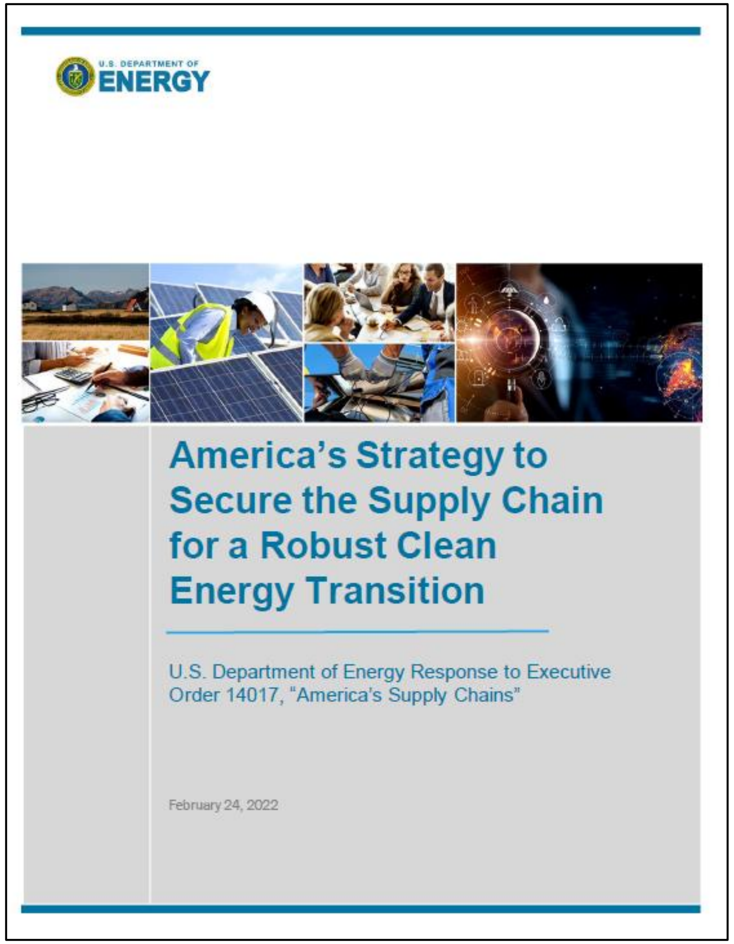
SUCCESS

REAL-TIME PROCESS CONTROL FOR GLASS MANUFACTURING

- Develop a machine-learning algorithm that can be run off of a desktop computer to replace the computational fluid dynamics model
- Make real-time, online adjustments by leveraging the new fast-running prediction tool
- Increase productivity in other industries using similar tools

HPC4 MANUFACTURING

Securing America’s Clean Energy Supply Chain



https://www.energy.gov/policy/supplychains

<u>11 deep dive assessment documents</u>:

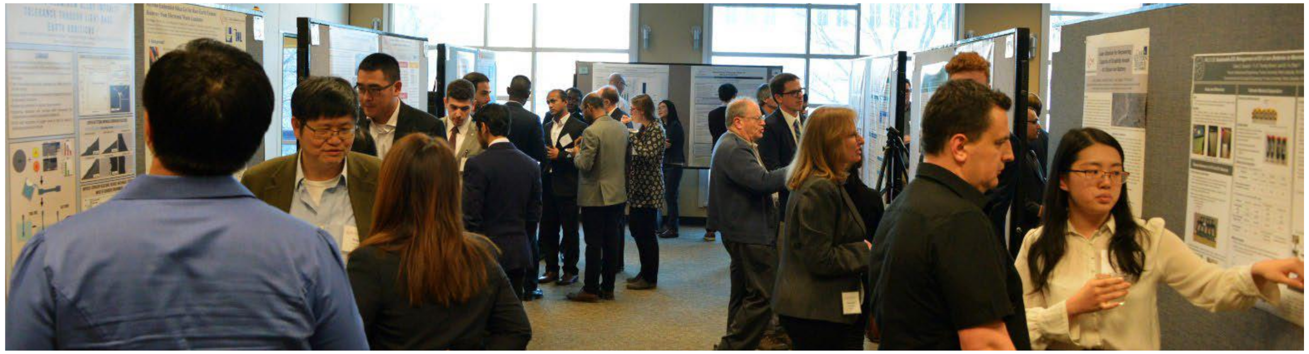
- carbon capture materials,
- electric grid including transformers and high voltage direct current
- energy storage,
- fuel cells and electrolyzers,
- hydropower including pumped storage hydropower (PSH),
- neodymium magnets,
- nuclear energy,
- platinum group metals and other catalysts,
- semiconductors,
- solar photovoltaics (PV), and
- wind.

<u>2 crosscutting topics</u>:

- commercialization and competitiveness, and
- cybersecurity and digital components.

Critical Materials Institute – an Energy Innovation Hub (CMI Hub)

People: 250+ strong, bolstered by education and workforce development
Innovative Ecosystem: network of 45+ active team members across critical material supply chains
Portfolio: 41 early-stage research projects that have resulted in 400+ publications and 150+ inventions

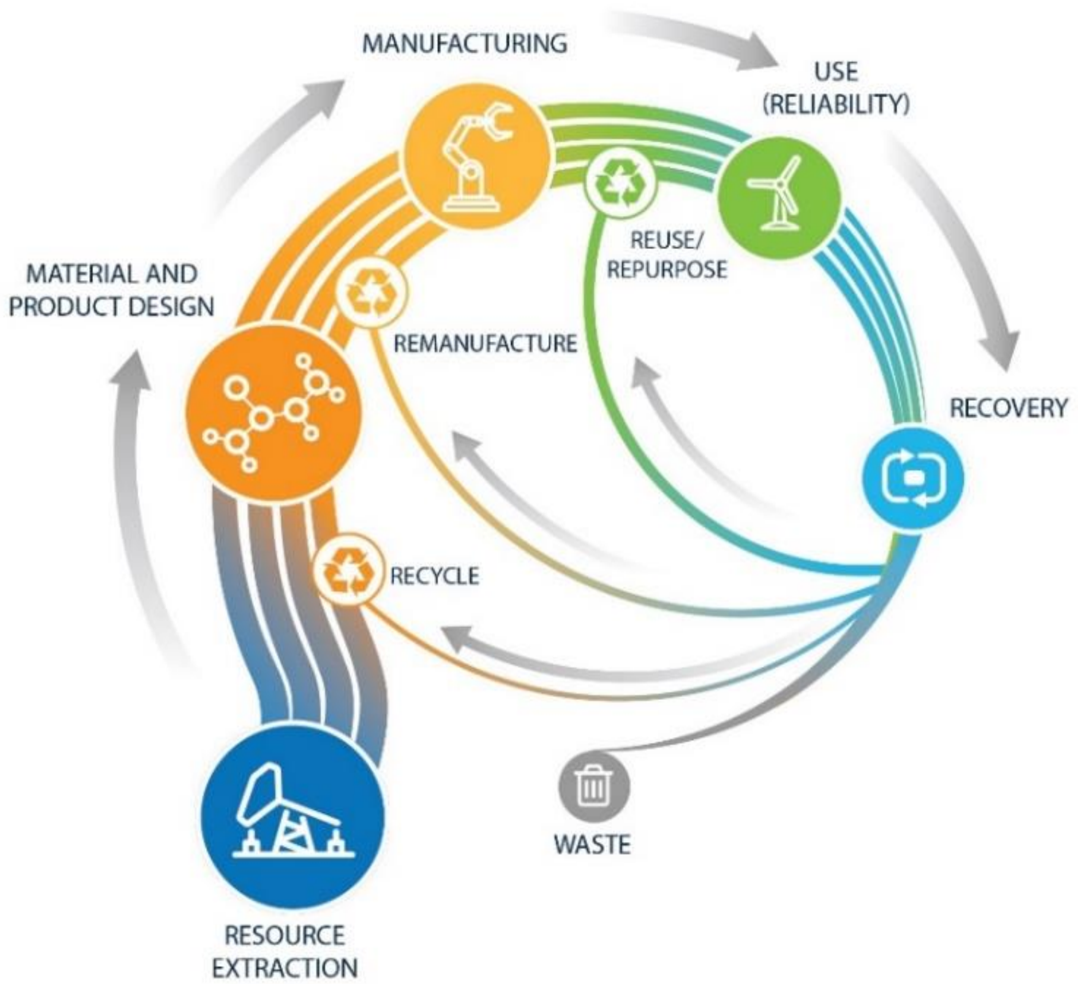


- **Diversifying Supply**
  - Expanded Sources
  - Transformational Processing
  - New Uses for Co-Products
- **Developing Substitutes**
  - Magnets with Reduced RE Content
- **Driving Reuse & Recycling**
  - Energy Storage Systems
  - Enabling & Optimizing Co-Production
  - Electric Machines
- **Crosscutting Research**
  - Enabling Science
  - Environmental Sustainability
  - Supply Chain & Economic Analysis

Permanent Magnets | Energy Storage | Electronics

A Circular Economy Can Also Help Reduce Carbon Emissions

- Total emissions reduction potential from Circular Economy pathways is estimated :
  - Material efficiency – 10%
    - Product design
    - Waste reduction
    - Lightweighting
  - Reuse/Repurpose – 12%
    - Longer usable lifetimes
    - Repair and remanufacturing
  - Recycling – 18%
    - Supply chain logistics
    - Design for circularity
    - Improved recycling processes
    - Improved separation/purity



Ellen MacArthur Foundation, Completing the picture: How the circular economy tackles climate change (2021)

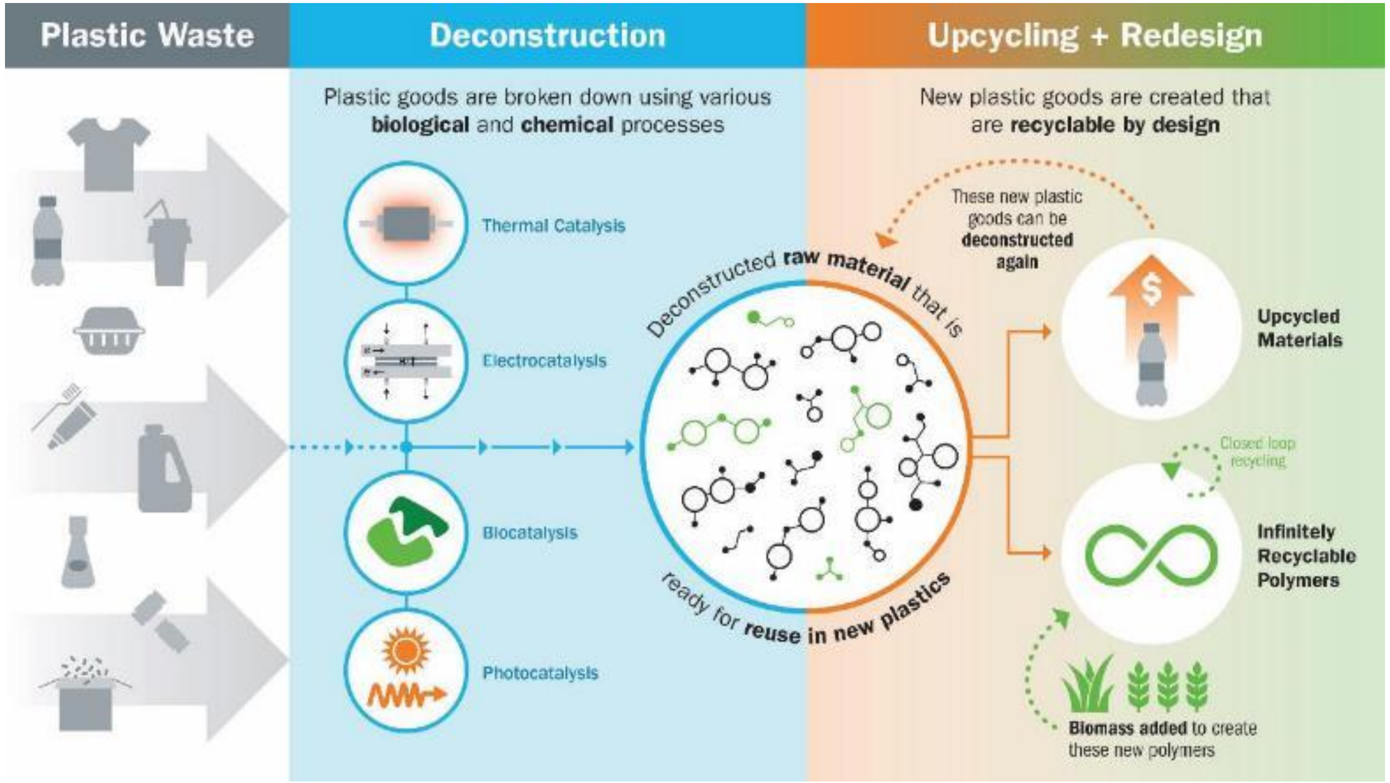
BOTTLE Consortium

The **vision** for BOTTLE is to deliver selective, scalable technologies that enable cost-effective recycling, upcycling, and increased energy efficiency for plastics.

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

The **goals** of BOTTLE are:

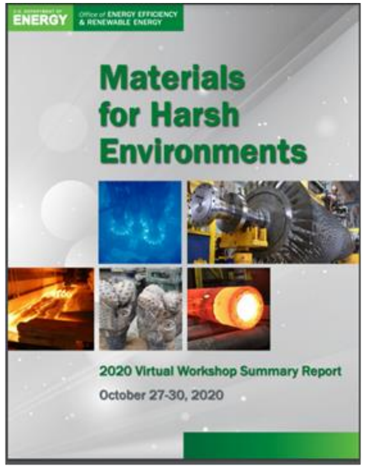
- Develop processes to deconstruct and upcycle today's plastics
- Design tomorrow's plastics to be recyclable and develop their recycling processes
- Work with industry to catalyze a new upcycling paradigms
- Leverage DOE investments in process development, catalysis, materials, and analysis-driven R&D



More information can be found at www.bottle.org

High Performance Materials

Materials for Harsh Service Conditions



Operational and Performance Metrics Targets

Description	Rank
Materials that can withstand molten salts at 750°C	1
Low-cost materials compatible with sCO_2 at 720°C to achieve above 50% efficiency	2
Improved materials for heat exchangers	3
Hydrogen-resistant materials	4

Materials with Enhanced Conductivity

International Annealed Copper Standard (IACS) set in 1913 as 100% IACS = 58.1 X10^6 Siemens /meter at 20°C.

Element	%IACS	Notes
Silver (Ag)	108.6	Used for premium applications
Copper (Cu)*, annealed	100	Most used because it is less expensive than silver with other good properties. Commercial electrolytic Cu ~101 % IACS.
Copper (Cu), pure	102.7	Pure Cu has poor mechanical properties.
Gold (Au)	70.9	Most costly-- used for premium applications when corrosion resistance is important
Aluminum (Al) alloy	~62	Second most used, mainly in an alloy. For power lines AA1350 with conductivity 61-62.4% depending on purity is used as it is cheapest, lightweight and flexible.

Electrical Conductivity Enhancement Goals

- **Ag-enhanced: >113% IACS**
- **Cu-enhanced: >109% IACS**
- **Al-enhanced: >67% IACS**
- **Nonmetal-enhanced: >50% IACS**

These goals must be met at the microscale.

For this contest, microscale means one gram minimum sample size.

CABLE Prize Official Rules document, Table 2. Defining Significant Enhancements

AMO's Technical Assistance Programs

- Public /private partnerships to help manufacturers and industrial organizations set and achieve long-term energy intensity reduction goals
- Education and training for the current and future manufacturing workforce
- No-cost tools and resources for manufacturers to improve energy efficiency and competitiveness
- End-user support, stakeholder engagement, and technical services for the industrial sector

PROGRAMS INCLUDE:	BETTER PLANTS	INDUSTRIAL ASSESSMENT CENTERS	50001 READY & SEP 50001	COMBINED HEAT & POWER TECHNICAL ASSISTANCE PARTNERSHIPS

AMO Education and Workforce Development Programs

K-12

TRADE SCHOOL

COMMUNITY COLLEGES

UNDERGRAD

GRADUATE

WORKFORCE

INNOVATORS

Energy Storage Internship Program

Industrial Assessment Centers

Better Plants Program

50001 Cohorts

Lab-Embedded Entrepreneurship Program

AMO R&D Consortia Education and Workforce Development Efforts

Build4Scale

Technical Partnerships Engagement

Technology Commercialization Fund

Enhanced Preparation for Intelligent Cyber-manufacturing Systems (EPICS) | Georgia Tech

Energy I-Corps

MS and MENG in Advanced Manufacturing for Energy Systems | University of Connecticut

Robotics Internships

Power Electronics Traineeships
Virginia Tech | University of Tennessee - Knoxville

AMO's Clean Energy Manufacturing Innovation Institutes

EXISTING INSTITUTES

PowerAmerica (2014): Wide-bandgap semiconductors

Institute for Advanced Composites Manufacturing Innovation (2015): carbon fiber composites

Clean Energy Smart Manufacturing Innovation Institute (2016): smart manufacturing

Rapid Advancement of Process Intensification Deployment (2017): chemical process intensification

Reducing EMbodied-energy And Decreasing Emissions Institute (2017): recycling and remanufacturing

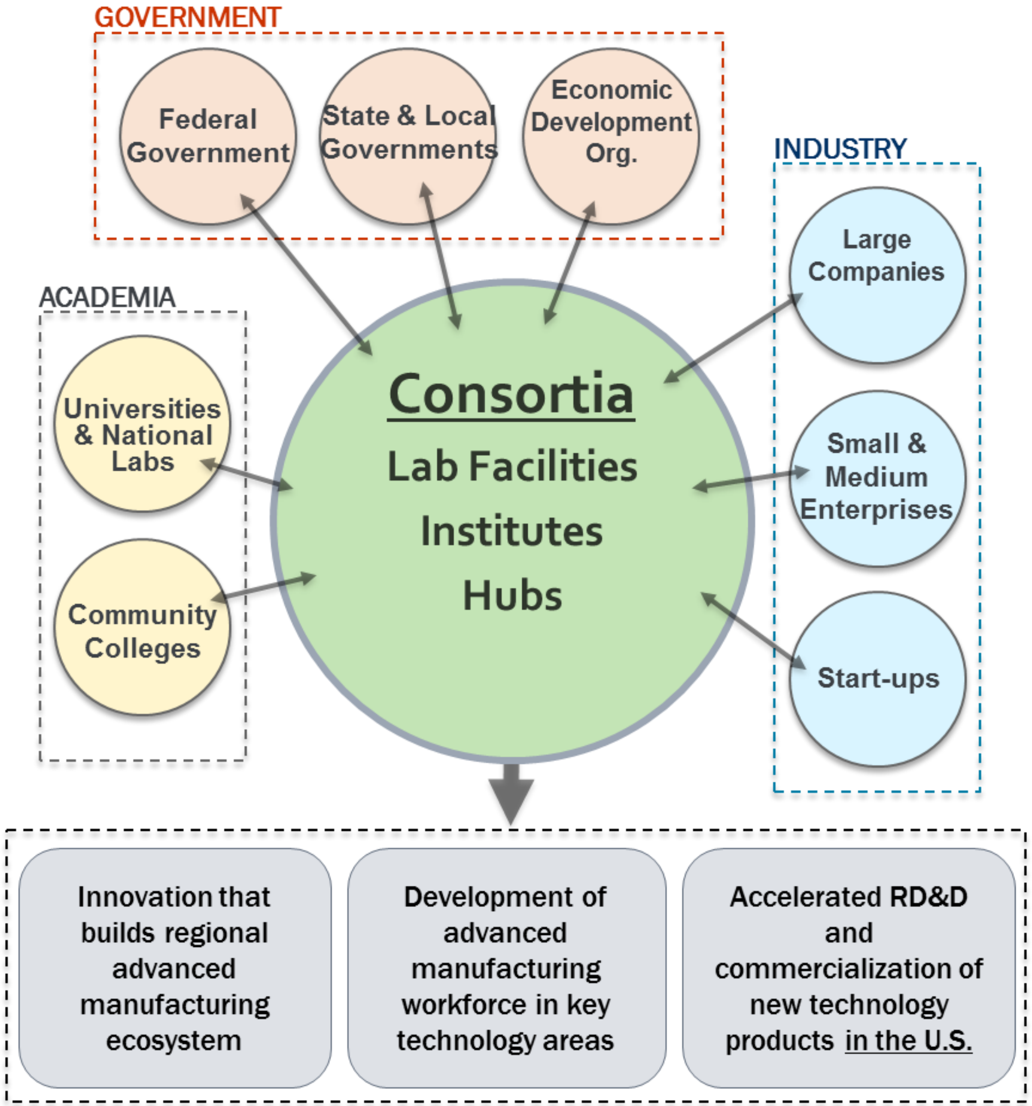
Cybersecurity Manufacturing Innovation Institute (2020): energy efficient, cyber-secure manufacturing

A FOA is currently open for a 7th Institute to address industrial decarbonization through electrification of process heating. An informational webinar will be held on July 14.

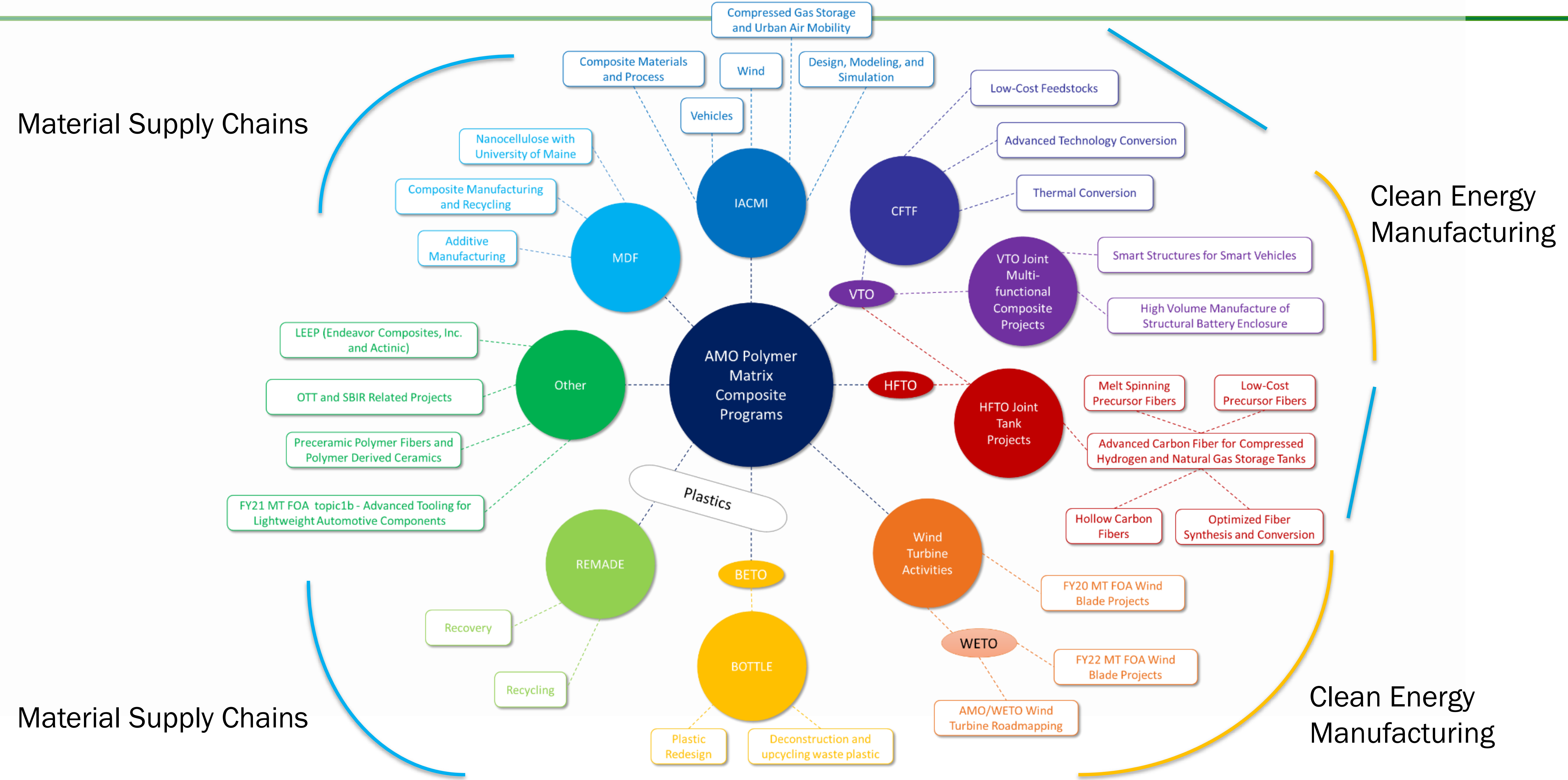
Institutes are Integral to Achieving AMO's Priorities

- **For key technology areas, a portfolio of standalone R&D projects is not sufficient to address the challenges:**
  - Need for a coordinated R&D effort across the supply chain or market sector to make an impact
  - Education and Workforce Development
  - Connecting the manufacturing ecosystem

- **Each R&D Consortia should have:**
  - Clear technology focus
  - Technology Readiness Level suited to specific technology challenge
  - Ability to address critical challenges
  - A balanced portfolio of projects
  - Active membership from industry, academia, and national labs
  - Ability to leverage federal funding with non-federal cost share to catalyze a growing ecosystem



AMO Composite Investments Serve Many Applications



AMO Composites Objectives

Advance composite design concepts and production technologies for materials and parts that

(1) improve material properties

(2) reduce embodied energy and emissions over multiple lifecycles

(3) reduce cost

Enable next generation composites to drive advances in energy- and decarbonization-related technologies.

Thank you

For additional information
and to subscribe for updates:

manufacturing.energy.gov