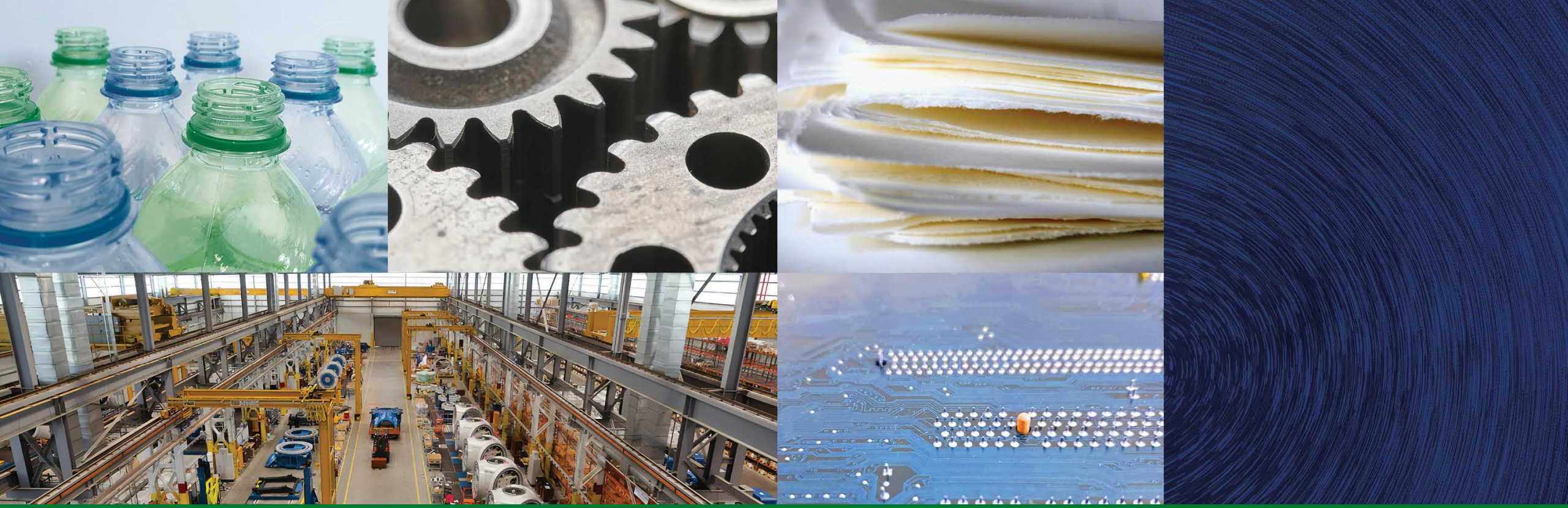

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REMADE Institute| AMMTO
Accelerating the Transition to a Circular Economy

Dr. Nabil Nasr, REMADE CEO; Dr. Magdi Azer, REMADE CTO

DE-EE0007897| Jan 2017 – Dec 2025

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The REMADE Institute

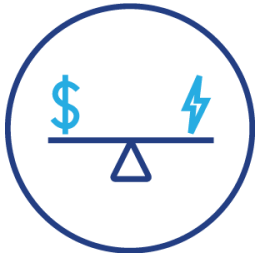
*A national consortium of **171 member organizations** comprised of industry, academia, national laboratories, trade associations, and non-profit entities collaborating on early stage applied research activities and the development & dissemination of key industrial technology initiatives*

REMADE STRATEGIC GOALS

Develop **transformational technologies** to expand material recycling, recovery reuse and remanufacturing

Reduce **energy use & emissions** by **decreasing primary, or raw and virgin, material use** in energy-intensive industries

Replace **primary feedstocks, or raw and virgin materials,** through **increased use of secondary feedstocks, or recycled materials**



Achieve **better than cost & energy parity** between secondary feedstocks & primary feedstocks

Educate and train the **incumbent & future workforce** to deploy and use REMADE technologies

Member Input
Market Dynamics
Techno Economic Analysis

→ Technology Roadmap
Strategic Investment Plan
Project Portfolio

→ Commercialization

	1/17 – 1/21	2/21 – 9/23	10/23 – 9/24	Total Planned $
DOE Funded	$9,937,899	$50,048,505	$10,013,596	$70,000,000
Project Cost Share	$9,982,343	$50,048,505	$9,969,152	70,000,000

REMADE TECHNICAL PERFORMANCE METRICS

↓30%
Primary Feedstock (FS) Consumed

↑30%
Recycled Materials Use

↑25%
Embodied Energy Efficiency

↓20%
GHG Emissions

→
←
Cross-Industry Reuse

Cost and Energy Parity

 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.

REMADE Mission:

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

Systems Analysis & Integration

Data collection, standardization, metrics, and tools for understanding material flow

Design for Re-X

Design tools to improve material utilization and reuse at End-of-Life (EOL)

Manufacturing Materials Optimization

Technologies to reduce in-process losses, reuse scrap materials, and utilize secondary feedstock in manufacturing

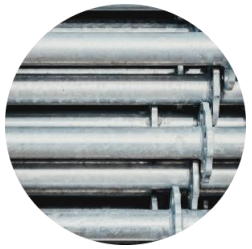
Remanufacturing & EOL Reuse

Efficient and cost-effective technologies for cleaning component restoration, condition assessment, and reverse logistics

Recycling & Recovery

Rapid gathering, identification, sorting, separation, contaminant removal, reprocessing and recycling

MATERIAL CLASSES



Metals

Polymers/Plastics

E-Scrap

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.

REMADE Membership

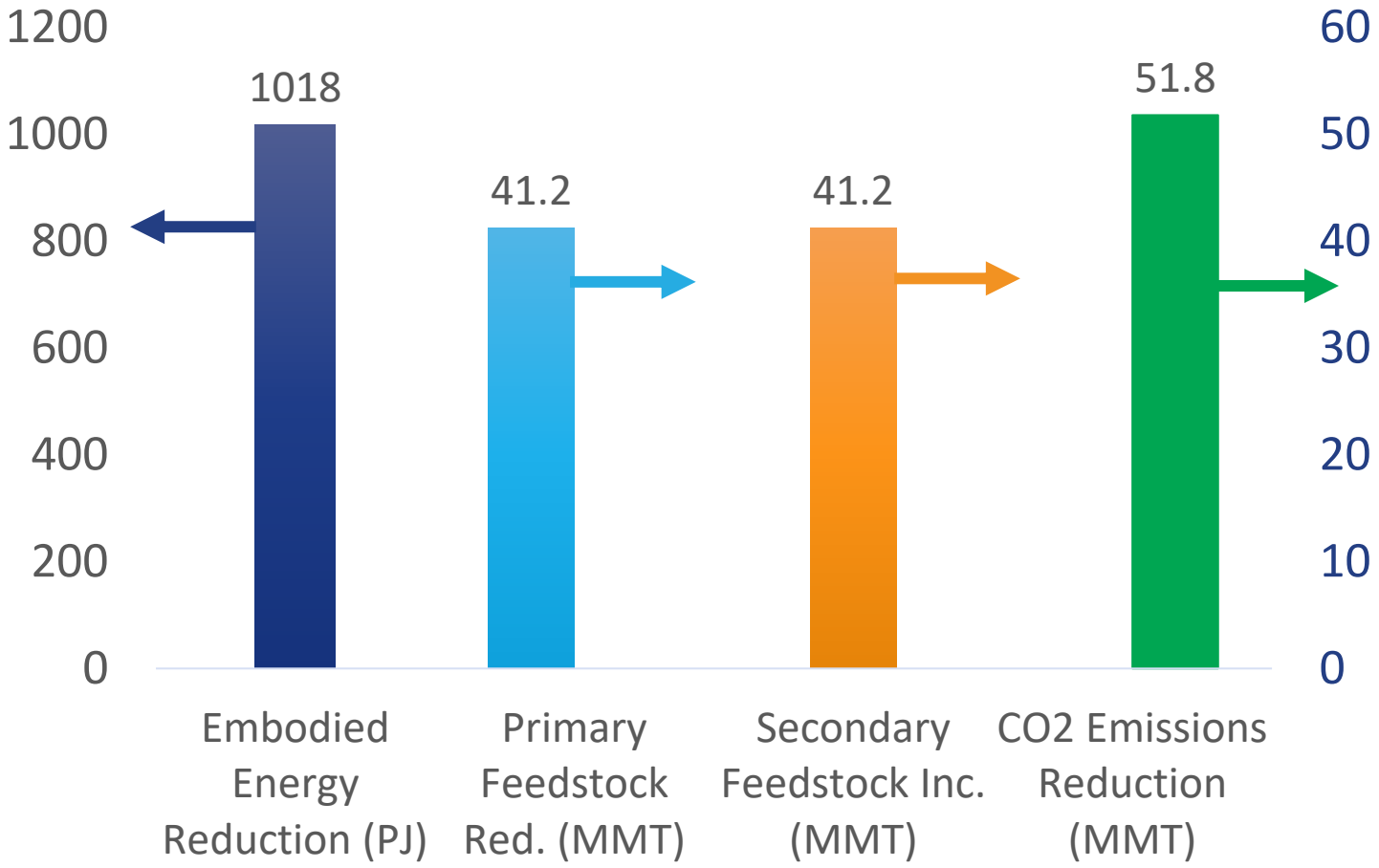
171
Members

- **91** Industry Members
- **40** Academic Partners
- **33** Affiliate Orgs.
- **7** National Labs

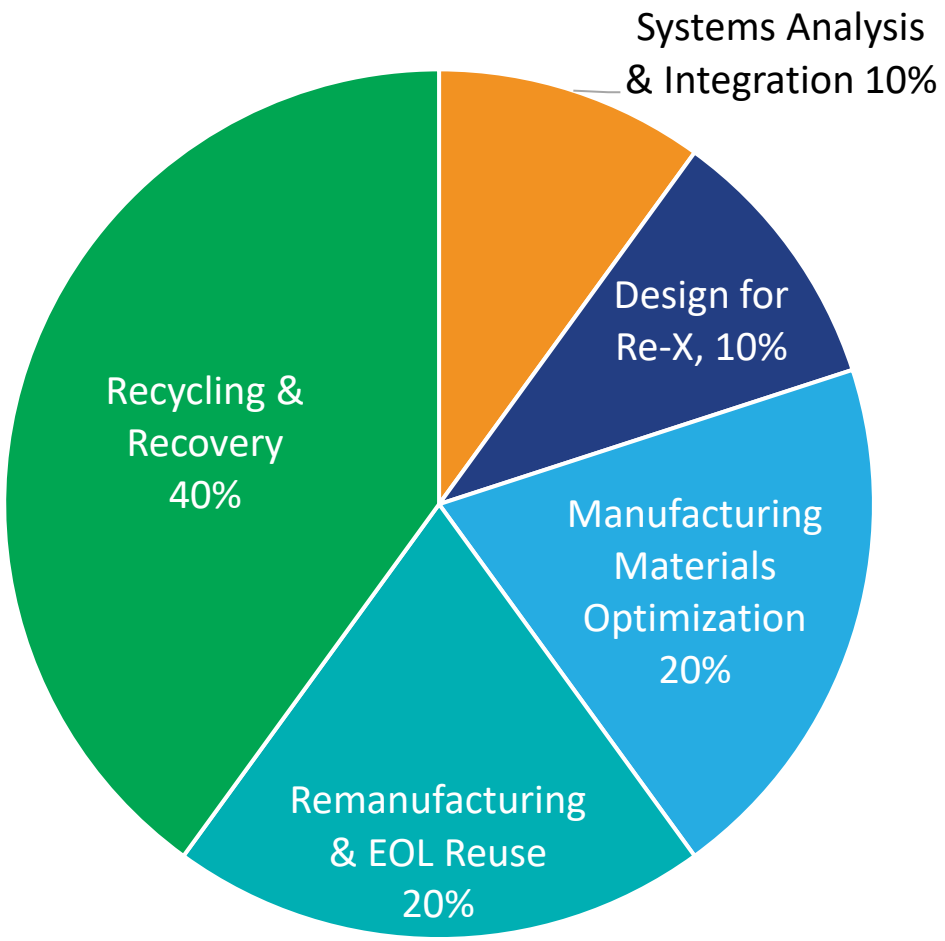
Light Metal Consultants, LLC | Kent County Department of Public Works | SER North America | TG-Companies | University of Dayton | Washington State University | American Honda Motor Co., Inc. Volvo | Sandia National Lab | A3 Global | University of Wisconsin-Madison | Reverse Logistics Association

Aligning Institute Investments with Technology Development Progress & Gaps

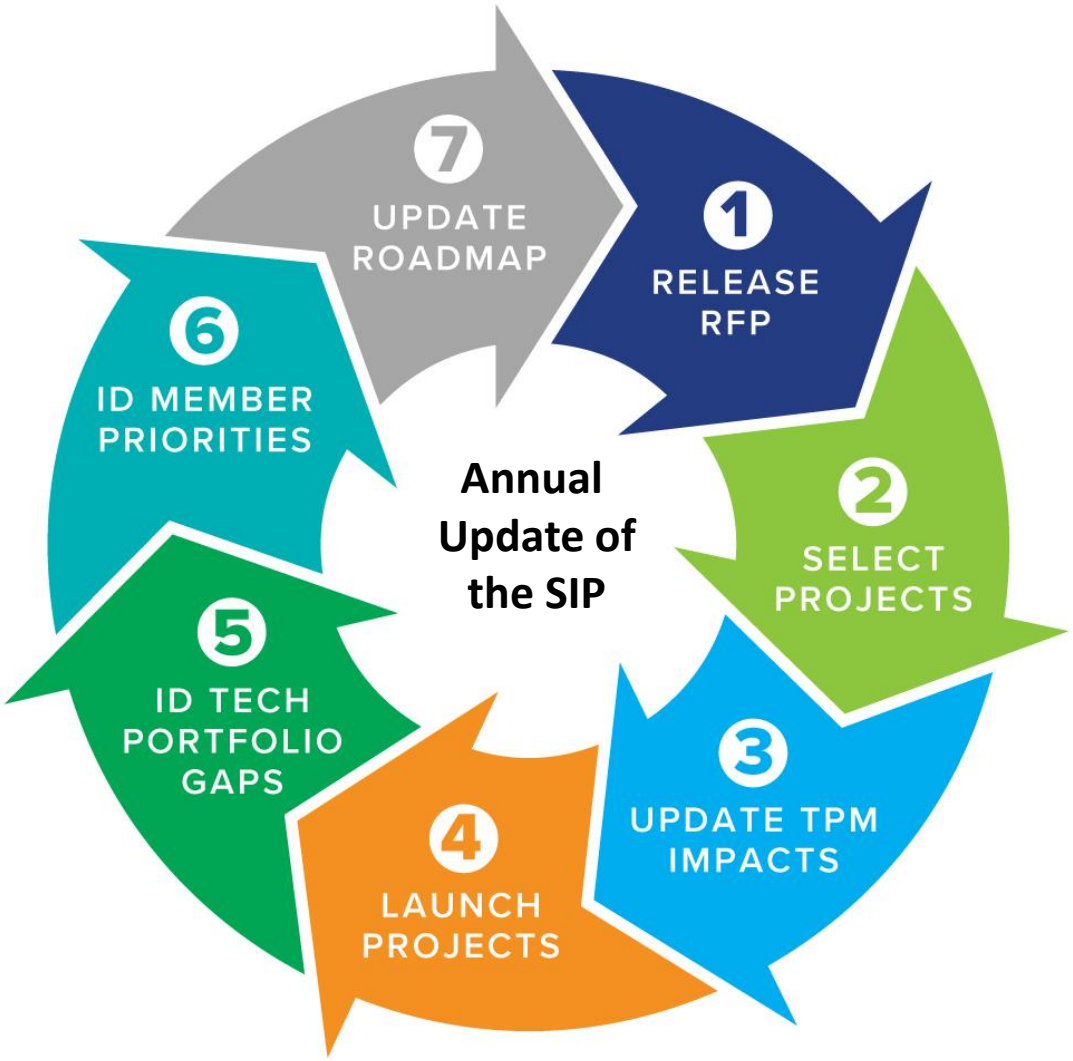
Annual Impacts of REMADE Project Portfolio
(for all Nodes after $70M Investment from AMMTO)



Funding Allocations by Node
(based on the Strategic Investment Plan)



Aligning Institute Investments with Technology Development Progress & Gaps



Technology Roadmap

- Identify the knowledge gaps and research priorities

Project Portfolio Analysis

- Calculate progress versus the Technical Performance Metrics (TPMs) & alignment with the Technology Roadmap

Strategic Investment Plan (SIP)

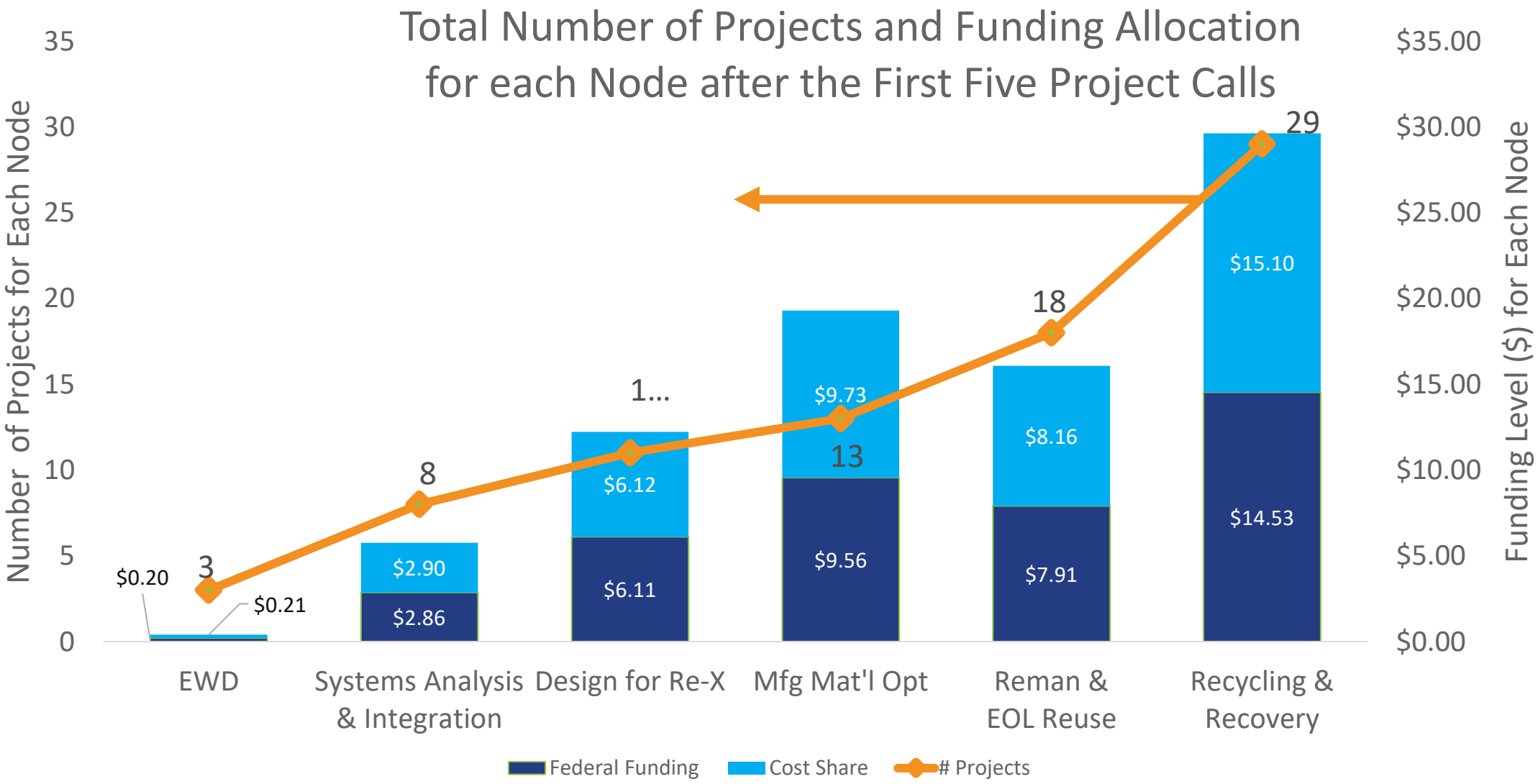
- Plan for research investment based on the technology roadmap and portfolio analysis

Request for Proposal (RFP)

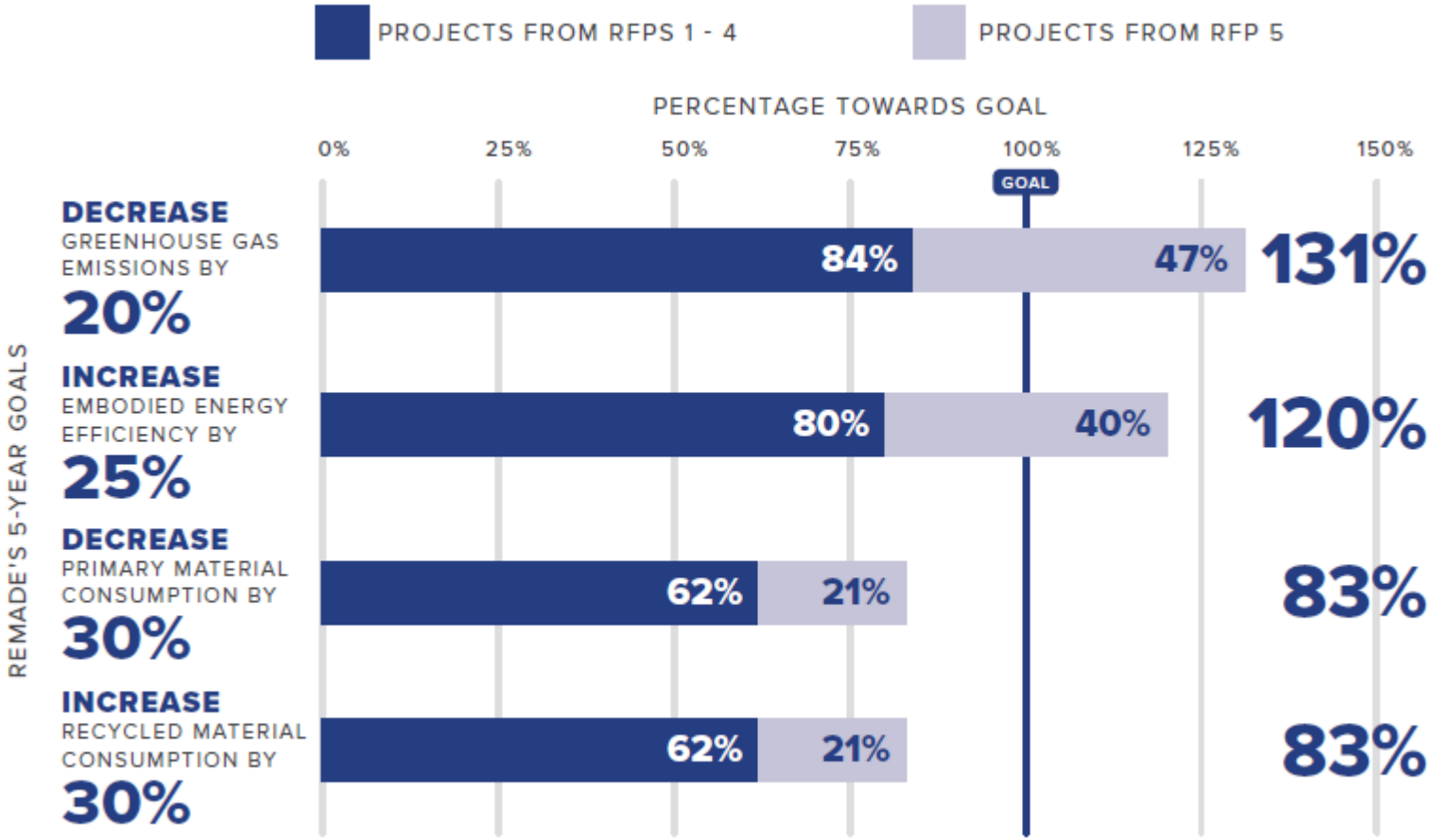
- Solicitation to address the research priorities of the roadmap, tech portfolio gaps consistent with the SIP funding levels

 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.

Total Number of Projects for each Node vs. the SIP through RFP 5



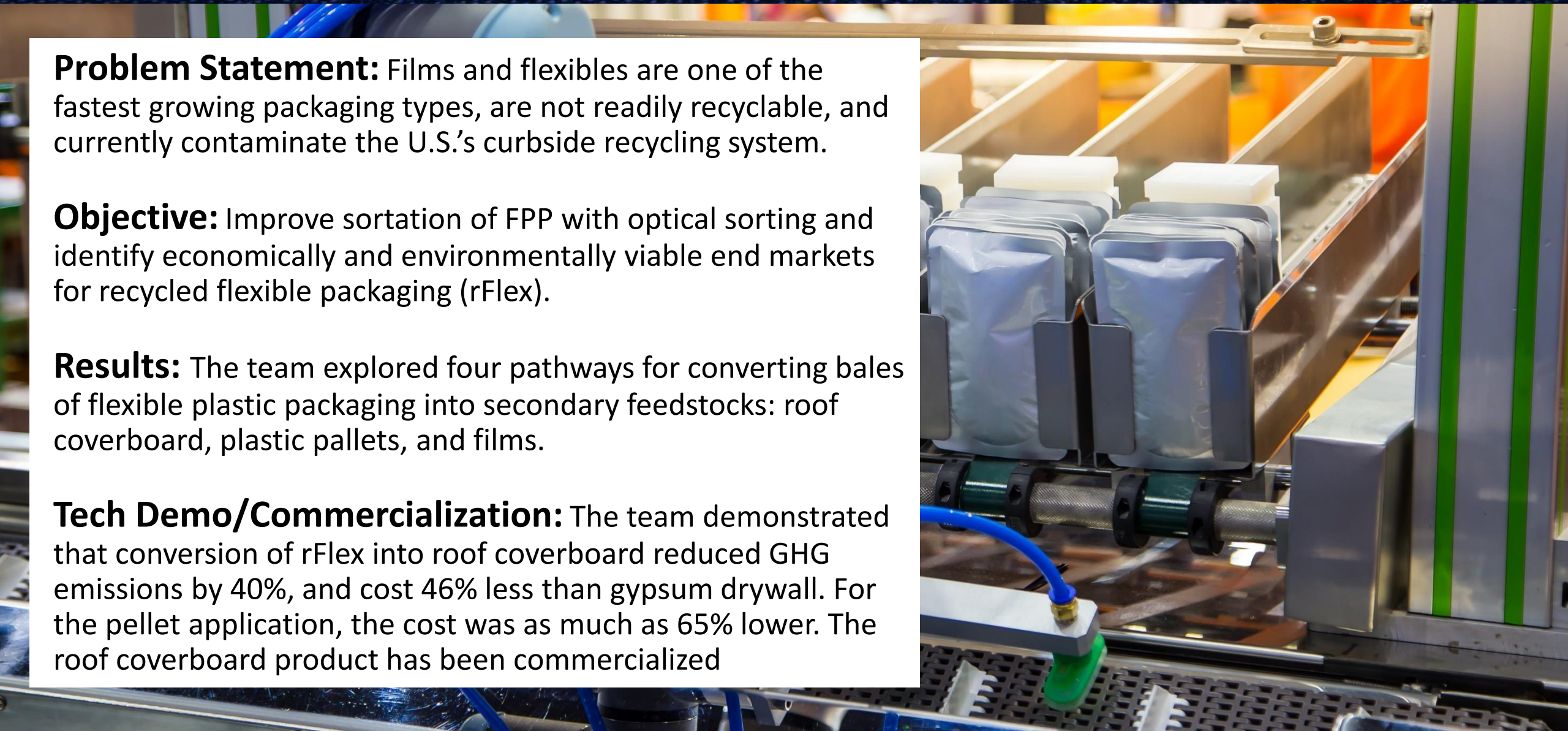
Technical Performance Metric Impacts of the Technology R&D Portfolio



These calculations represent the estimated potential impact of projects in the R&D portfolio

 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.

Sorting and Recycling of Mixed Flexible Packaging & Plastic Wrap



Problem Statement: Films and flexibles are one of the fastest growing packaging types, are not readily recyclable, and currently contaminate the U.S.'s curbside recycling system.

Objective: Improve sortation of FPP with optical sorting and identify economically and environmentally viable end markets for recycled flexible packaging (rFlex).

Results: The team explored four pathways for converting bales of flexible plastic packaging into secondary feedstocks: roof coverboard, plastic pallets, and films.

Tech Demo/Commercialization: The team demonstrated that conversion of rFlex into roof coverboard reduced GHG emissions by 40%, and cost 46% less than gypsum drywall. For the pellet application, the cost was as much as 65% lower. The roof coverboard product has been commercialized

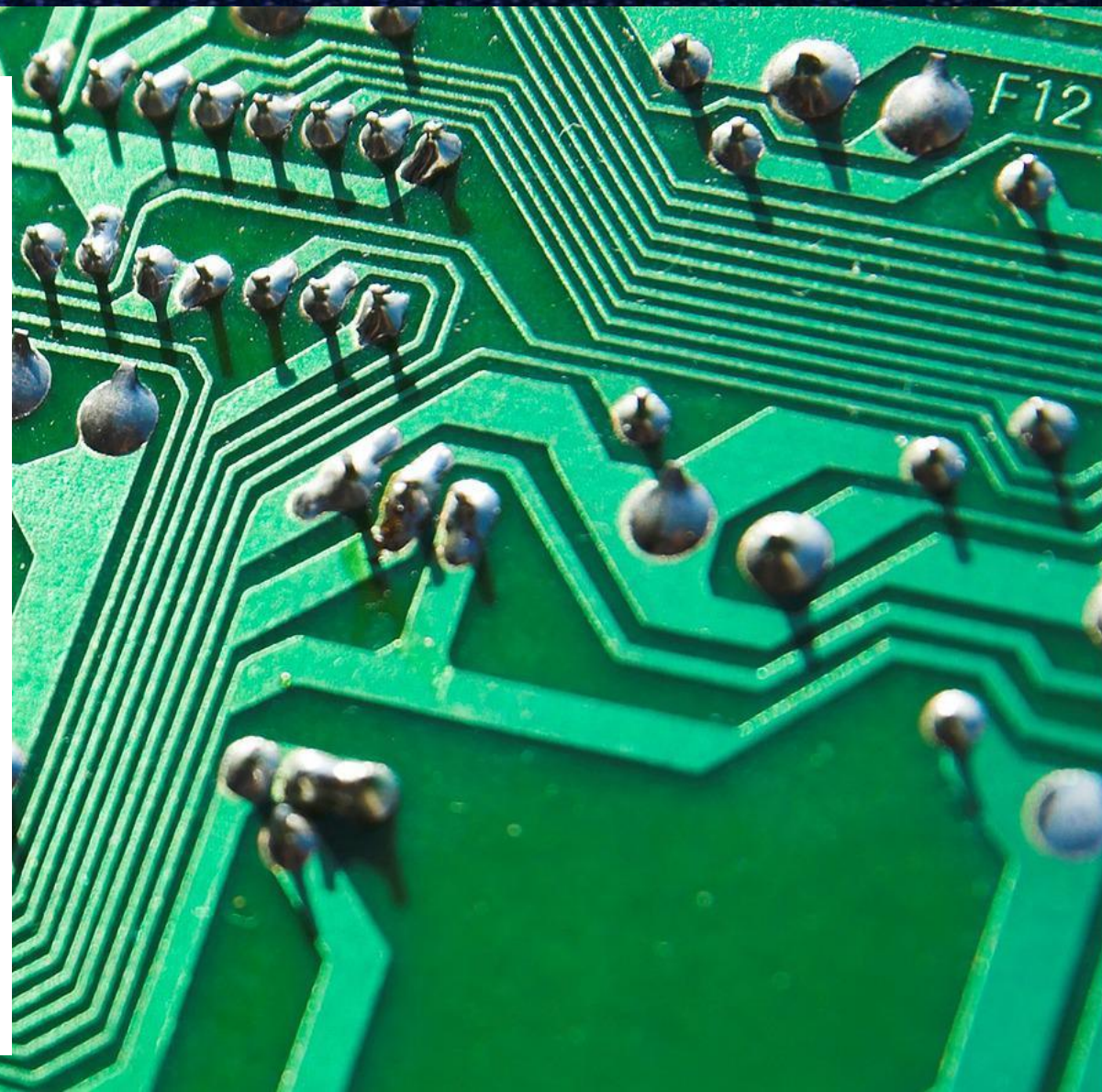
Metal Recovery Using Gas-Assisted Microflow Solvent Extraction (GAME)

Problem Statement: Only 20% of e-scrap is recycled through appropriate channels, and the recycling rate of precious metals from scrap PCBs is even less

Objective: Design, construct & evaluate a gas-assisted microflow extraction (GAME) system to recover precious metals from complex streams generated from PCBs.

Results: Once fully developed, the team expects to increase the precious metal recycling rate in PCBs to 60%.

Tech Demo/Commercialization: The team has licensed the technology being developed to Phinix LLC.



Enabling More Recycled Rubber in Tires

Problem Statement: Today, the amount of micronized rubber powder (MRP) used in light-duty and commercial vehicle tires is 0.1% and 0.4%, respectively.

Objective: Increase the amount of MRP in light-duty and commercial vehicle tires to 12% and 15%, respectively.

Results: The team has developed multiple new composite polymer material formulations containing virgin rubber and MRP

Tech Demo/Commercialization: The team has fabricated 12 passenger vehicle tires and 12 truck tires on full-scale production equipment and is evaluating tire endurance relative to baseline new tires.

Detection of Hidden Defects in Used Circuit Boards

Problem Statement: Methods to reliably & cost-effectively detect/locate defects in printed circuit boards (PCBs) limits PCB remanufacturing.

Objective: Develop automated artificial intelligence-based methods to detect latent failures in used PCBs.

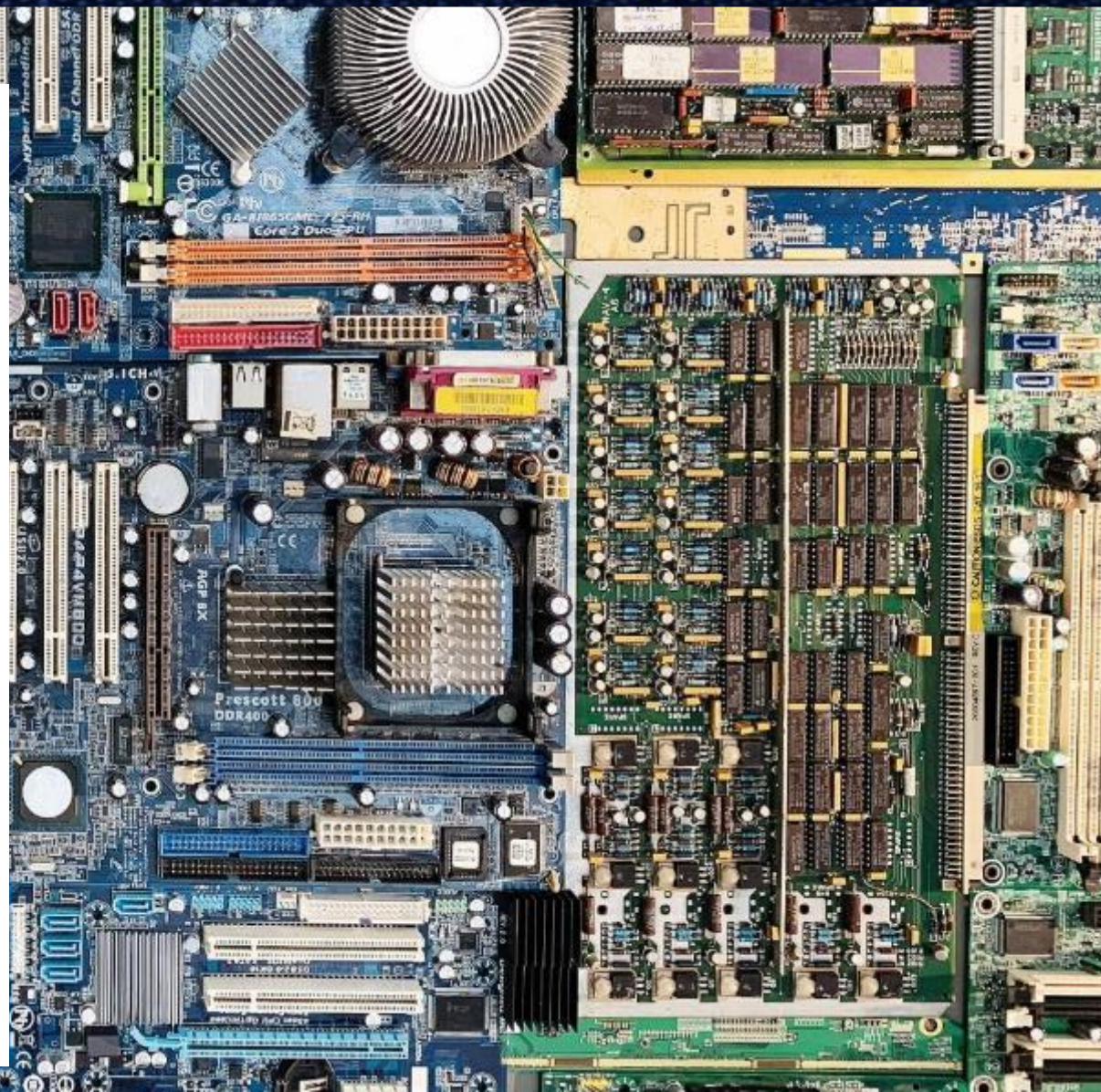
Results: Based on results to-date, the team expects to be able to increase PCB reuse by 25-35%.

Tech Demo/Commercialization: The team installed a prototype system at CoreCentric Solutions to continue refining the process

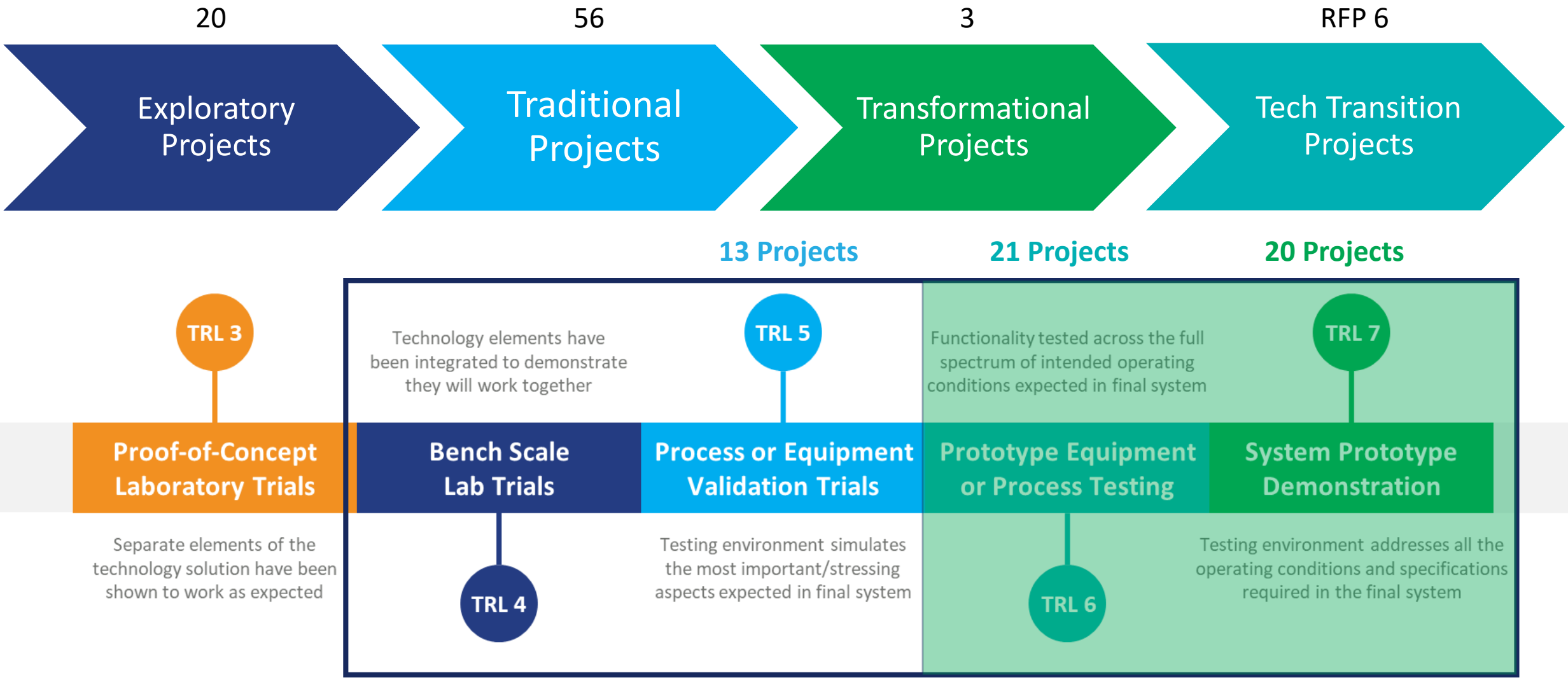
RIT

CoreCentric Solutions Inc.
Adding Value from Start to Finish

CATERPILLAR®



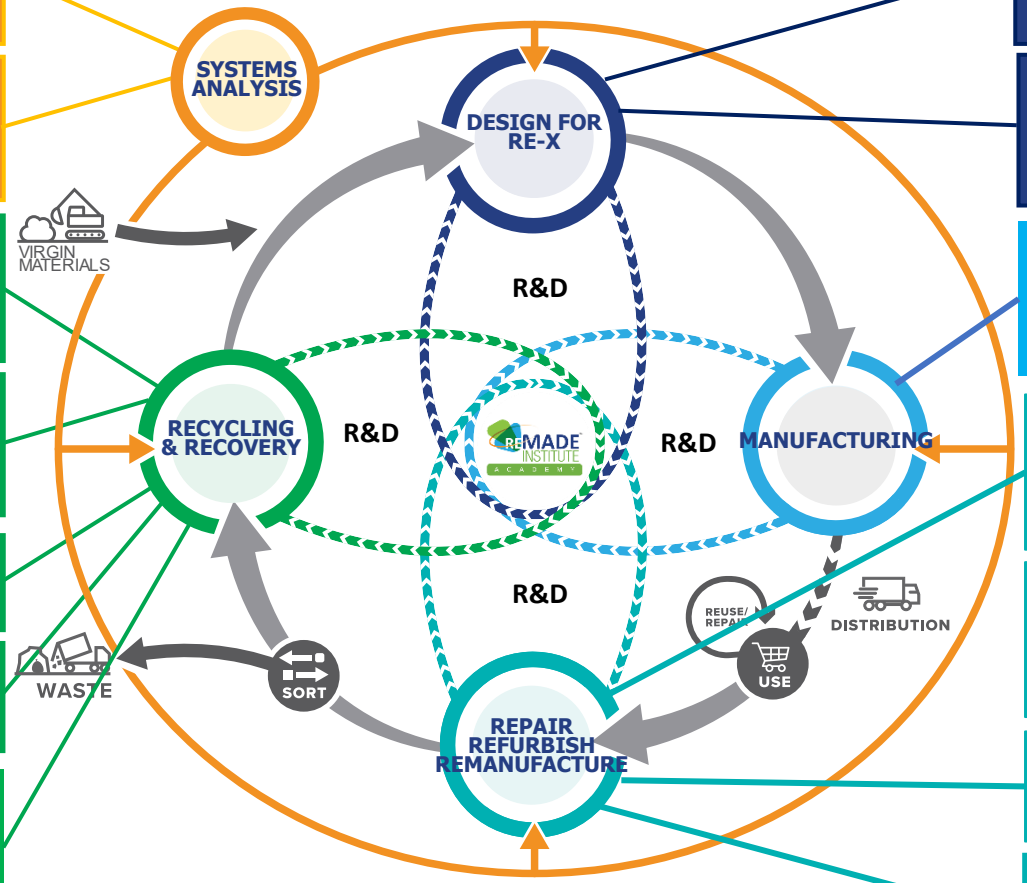
Maturing & Transitioning Technology



REMADE Academy

Training Industry for Next-Generation Circular Economy Technologies

- "Systems Analysis Tools & First Insights from REMADE Projects" Certificate
- "Systems Thinking in Material Management" Certificate
- "Fundamentals of Mechanical Recycling of Plastics" Certificate
- "Emerging Trends in Plastics Recycling" Certificate
- "Chemical Recycling of Plastics" Certificate
- "Advanced Fibers Recycling" Certificate
- Advanced Materials Separation Technologies Certificate **Future Dev.*



- "Design for Re-X Introductory Fundamentals"
- Design for Remanufacturing, Recycling, and Reuse Certificate **Future Dev*
- Simulation Techniques to Optimize Material Use in Manufacturing & Recycling
- Reverse Logistics for Remanufacturing Certificate **Future Dev*
- Cleaning for Remanufacturing Certificate **Future Dev*
- Condition Assessment for Remanufacturing Certificate
- "Fundamentals of Remanufacturing" Certificate

- Introducing Industry to the Circular Economy Across 5 focus areas
- Over 3,100 participants, including 500+ self-identified trainers
- Training prepared for both on-site and online-delivery; supported with over 20 R&D project training webinars
- Guided by Industry Led Education Committee

 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-EE0007827.

REMADE CIRCULAR ECONOMY TECH SUMMIT & CONFERENCE

BREAKTHROUGH INNOVATIONS FOR SUSTAINABLE MANUFACTURING.

REMADE INSTITUTE

IN PARTNERSHIP WITH:

ELLEN MACARTHUR FOUNDATION

SUPPORTED BY:

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

REMADE INSTITUTE

INITIATIVES

MRFNXTGEN™

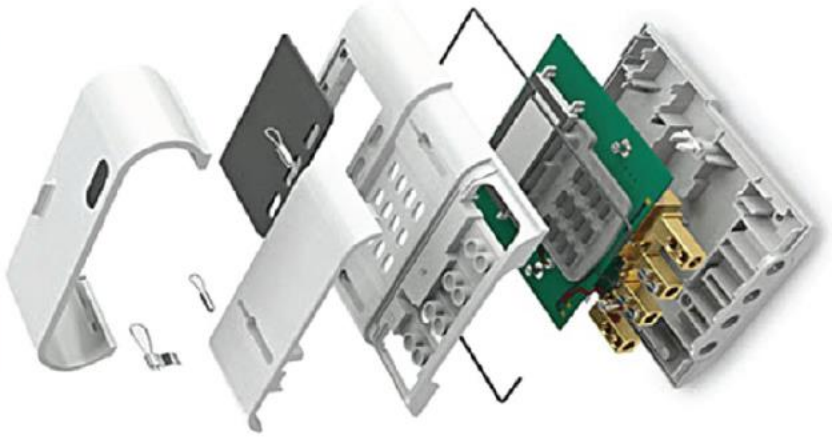
PLASTIC RECYCLING

SYSTEMS ANALYSIS

FULL EV RECYCLABILITY

DIGITAL REMAN

CIRCULAR DESIGN



Examples of REMADE Material Recovery R&D

Novel Sorting Technologies

Rapid Sorting of Scrap Aluminum Sorting & Recycling of Mixed Flexible Packaging

Contamination Removal

Purification of Recycled Metals, Fibers, and Plastics

Artificial Intelligence

Identification of Mixed Plastic & Valuable Electronics / Contaminant Removal from Recycled Plastics

Improved Material Recovery

Low-Cost, High-Value Metal Recovery from Electronic Scrap

Novel Waste Processing Methods

Delamination to Enable Recycling of Polymer-Based Multilayer Packaging

Condition Assessment

Condition Assessment of Used Electronics and Non-Destructive Evaluation of Metal Fatigue Damage

 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.

Results and Achievement

Projects

- 79 Technology/3 EWD Projects have been selected for funding
- 29 Projects Completed, 51 Active Projects, Reviewing 45 proposals submitted for RFP 6
- 20 Projects on track to reach TRL 7/21 Projects on track to reach TRL 6

Technology Transfer & Dissemination

- 18 subject inventions reported by project teams
- 2 Technology licenses negotiated
- 75+ articles/presentations that have been published, are awaiting publication, or publicly presented
- Inaugural CE Conference & Tech Summit held – to be published. Working to launch a new journal.

Technical Performance Metrics

- Tech portfolio capable of reducing embodied energy by 1.2 Quads/yr, decreasing primary material increasing secondary consumption by 36.2 MMT/yr, and reducing CO_2 emissions by 68.9 MMT/yr

Membership

- 171 REMADE members (vs. 95 members at the 2020 Peer Review)

Education & Workforce Development

- 70+ hours of online EWD content has been released, 9 certificate pathways released, 3,100 trained

 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.

Future Work, Technology Transfer, and Impact

Future Work

- Select and launch projects from RFP 6
- Start up the REMADE Initiative for MRFNxtgen

Technology Transfer

- RFP 6 is focused on scaling previously developed technologies to TRL 6 or TRL 7
- Continue patenting and licensing REMADE technologies
- Utilize testbeds and technology incubators to commercialize REMADE technologies

Impact

- Tech portfolio capable of reducing embodied energy by 1.2 Quads/yr, decreasing primary material increasing secondary consumption by 36.2 MMT/yr, and reducing CO_2 emissions by 68.9 MMT/yr
- Expand existing EWD content and tailor training to REMADE Members

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