EMbodied-energy And Decreasing Emissions (REMADE) Institute

ACCELERATING THE TRANSITION TO A CIRCULAR ECONOMY

U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
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Sustainable Manufacturing Innovation Alliance
Award Number DE-EE0007897
1/13/2017 – 12/31/2021

This presentation does not contain any proprietary, confidential, or otherwise restricted information.
## Institute Overview

### Schedule
- **REMADE** award issued Jan 2017 & funding released in May 2017
- Projected end date December 2021
- BP2 – Apr ‘18 – Jun ‘19
- Working on BP3 continuation application.
- 31 projects selected from first two project calls
  - 10 active projects/9 additional projects to launch at start of BP3
  - 12 projects from second project call to launch October 2019

### Budget
- $140M award, $70M federal / $70 match
- Received $10M from New York State to support cost share
- Institute is meeting the 1:1 cost share requirement
- Fiscal year 2017/2018 audit successfully completed
- Receivables and payables current, including annual membership dues

### Membership
- 79 Members as of 5/16/19
  - 36 Industry
  - 15 Affiliate
  - 5 National Labs
  - 53% of industry members are small/medium sized businesses
  - 93% Retention Rate
  - 68 orgs have reached renewal period
  - 63 have confirmed renewal
  - 6 organizations joined in Q1 2019

### Challenges
- **Identifying Responsive Design for Re-X Projects** – First two project calls resulted in three Design for Re-X projects.
- **Timely RFP Development** – Have modified process for developing RFPs and the structure of Technology Roadmap to address this
- **Project Negotiation** – Delays negotiating/launching first 19 projects. Have modified process & developed SOPO/budget training materials
- **Roadmap Prioritization** – Trade-offs between starting new projects in roadmap vs continuing initial projects. Key BP3 focus for TAC/SAC
- **Cash Management** – reimbursement basis vs advance payment is challenging for an independent institute

REMADE Addresses Sustainable Manufacturing Technical Targets 14.1, 14.2, and 14.3 from AMO Multi-Year Program Plan (MYPP)
Project Objective:
Reduce embodied energy and carbon emissions through early stage applied research & development

REMADE STRATEGIC GOALS

- Enable greater utilization of secondary feedstocks which require less energy to produce for key materials
- Reduce primary materials consumption (and energy lost when they are landfilled) while achieving better than cost and energy parity for key secondary materials
- Promote widespread application of new technologies across multiple industries that expand material recycling, recovery, remanufacturing and reuse in US manufacturing

REMADE TECHNICAL PERFORMANCE METRICS (TPMs)*

- 30% reduction of embodied energy efficiency in 5 years
- 25% improvement in extended material feedstock processing by 34% in 5 years
- 30% reduction in primary material feedstock cost
- 20% reduction in material feedstock cost

REMADE Institute is aligned to directly support the AMO mission and strategic goals

* REMADE Addresses Sustainable Manufacturing Technical Targets 14.1, 14.2, and 14.3 from AMO MYPP
Why REMADE?

Global sales of plastic bottles ~ 1 million/minute
U.S. generates 9.4M tons of e-waste per year
U.S. Production of Aluminum & Steel
China consumes 55% of global paper scrap

Plastic Recycling Rate dropped to 4.4% in 2018
Represents 2% of MSW & growing at 4% annually
Accounts for ~10% of U.S. Manufacturing Energy Use
U.S. scrap paper sales to China down ~ 38%

Solving these issues requires a comprehensive systems level approach guided by national goals and metrics addressing industry needs and priorities with a path to implementation & commercialization

Technology Innovation – Current Technology Landscape

REMADE Members (5/16/2019)

- Diverse membership composition supports the mission and goals of the Institute
- Nationwide industry-focused consortium
- Member locations well aligned with labor markets corresponding to REMADE focus areas
- 45 member organizations are involved in Institute projects selected for award

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<td>Tier 3</td>
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TOTAL 79

Industry (46%)
Academic (29%)
Affiliate (19%)
National Lab (6%)
The REMADE Institute

A national consortium of 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

TECHNOLOGY FOCUS AREAS ORGANIZED AROUND 5 NODES DESIGNED TO ADDRESS CROSS-CUTTING CHALLENGES

- **Systems Analysis and 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

- **Recycling and Recovery**
  - Rapid gathering, identification, sorting, separation, contaminant removal, reprocessing and disposal

- **Remanufacturing/EOL Reuse**
  - Efficient and cost effective technologies for cleaning component restoration, condition assessment, and reverse logistics

**MATERIAL CLASSES**

- Metals
- Polymers
- E-waste
- Fibers

Technology Innovation – Organized by Stages of the Material Lifecycle

Project Portfolio

31 Projects
45 Collaborating Organizations
$15 Million Project Value

13 Projects
$7.7M Project Value
- Recycling and Recovery
- Remanufacturing
- EOL Reuse

7 Projects
$2.3M Project Value
- Systems Analysis and Integration

5 Projects
$2.6M Project Value
- Design for Re-X®

3 Projects
$0.6M Project Value
- Manufacturing Modularity

3 Projects
$1.7M Project Value
- Cost Reduction
Technical Approach – Identifying Research Activities that Enable REMADE to meet its TPMs

Focus of BP2 Technology Roadmap Update

• Conduct industry interview to refine roadmap content
• Develop strategy for meeting the TPMs based on energy/emissions/material impacts for mat’l classes
• Reorganize roadmap by Thrust Areas for each node
• Develop dashboard to strategically allocate resources

Research Activity Analysis Dashboard

• **Impact versus the TPMs**
  • Extent to which an activity contributes to achieving the REMADE’s goals and the TPMs

• **Importance to REMADE’s Research Portfolio**
  • Extent to which an activity is foundational to future work

• **Probability of Success**
  • Estimate of the relative difficulty of an activity relative to other activities

![Recoverable Energy (PJ), Energy Required to Process Secondary Materials (PJ), and Material Savings (MMT) for each Material Class](image)

![Research Activity Analysis Dashboard](image)
# Technical Approach - Material Classes Addressed & Project Impacts by Thrust Area

<table>
<thead>
<tr>
<th>Node Node</th>
<th>Thrust Area</th>
<th>1st RFP</th>
<th>2nd RFP</th>
<th>Material Classes</th>
<th>Project Impacts</th>
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<td>13th RFP</td>
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<td>14th RFP</td>
<td>Characterization, Cleaning &amp; Purification</td>
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<td>TOTALS</td>
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Delivering Impact Across Entire Material Lifecycle

**Solar Cell Performance & Lifecycle Mgmt (Design)**
- Balance Performance, Total Cost of Ownership, & Embodied Energy
- 25% Reduction in Embodied Energy

**Aluminum Die Casting (Manufacturing)**
- Double the Secondary Feedstock Used in Aluminum Die Casting
- Reduce Primary Aluminum Use by 0.16 MMT and Energy Use by 30 PJ

**Condition Assessment off Electronics (Reman)**
- Increase Reuse of PCBs in Heavy Equipment Applications
- Increase Reuse Yield by 25-35% and Reduce Energy Use by 42 PJ

**Developing Deinking Technologies (Recycling)**
- Develop Novel Deinking Technologies for Water Soluble Inks
- Recover 0.87 MMT of Paper and Reduce Energy Use by 42 PJ
Addressing Entire Value Stream for Film & Flexibles

Problem Statement
• One of the fastest growing packaging types
• Currently a contaminant to the curbside recycling supply chain
• Rejected at curbside or discarded into residue at Material Recovery Facilities
• 7 MMT of flexible films landfilled per year.

Relevant REMADE Projects
• Systems Analysis for PET and Olefin Polymers in a Global Circular Economy Determining Material, Environmental & Economic
• Efficiency of Sorting & Recycling Mixed Flexible Packaging and Plastic Wrap
• Scalable High Shear Catalyzed Depolymerization of Multilayer Plastic Packaging
Results and Accomplishments

✔ Projects
  • 31 Projects recommended from first two project calls (Apr ‘19)
  • First 10 projects launched and underway (May ‘19)
  • Remaining 21 Projects to begin in the next four months (Jul ‘19 – Oct ‘19)

✔ Technology Roadmap
  • Technology Roadmap updated (May ‘19)
  • Reorganized roadmap by Thrusts Areas and developed Dashboard to strategically assess portfolio
  • Update/alignment guided by member interviews and TLC analysis of which material classes and tech dev opportunities will deliver the greatest impact toward the TPMs

✔ Membership
  • Growing Membership – Currently 79 Members, 6 new Members in Q1, 93% Retention Rate

✔ Education and Workforce Development
  • Conducted industry interviews assessing EWD challenges (Feb ‘19). Feedback to be reflected in roadmap & future content development
  • Completed catalog of existing REMADE-relevant training opportunities
  • Workforce strategy updated to reflect incumbent workforce focus. BP3 training plan formulated (May ‘19)
  • Short courses in recycling and remanufacturing in development
  • Webinars – Plastic Recycling (Dec ‘18), Remanufacturing (Jan ‘19), E-Waste (May ‘19), and Metals Recycling (Jun ‘19)
REMADE Transition – Road to Sustainment

*Diversification in funding and sectors promotes an adaptable framework*

- Obtain industrial funding for corporate interest projects that address higher TRLs
- Diversify funding sources include other federal agencies
- Incorporate additional funding streams – private equity, VC
- Ensure ongoing participation from a cross-section of industries & sectors
- Develop membership option for cohort of states
- Secure state/regional economic development funding
- Create provisions for enabling municipalities to participate
- Patent novel technologies/processes and license IP that has been developed
- Continued dissemination of REMADE initiatives, activities, and accomplishments
- Leverage education and training opportunities through workforce development

**Core Activities (DOE Funding)**
- Basic Research
- Research to Address Knowledge Gaps and Prove Feasibility
- Technology Development And Demonstration

**Funded by Industry**
- Deployment

**Funding Diversification for Institute Self Sustainment**
- Federal Grants & Contracts, 30%
- State Consortia & Economic Development, 30%
- Memberships & Industrial Funding, 30%
- Technology Transfer & IP, 10%
## Projects by Thrust Area

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<thead>
<tr>
<th>Node</th>
<th>Technical Thrust</th>
<th>REMADE Project</th>
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<tr>
<td>Systems Analysis</td>
<td>Material Flow, Lifecycle Analysis, Methods, Tools, and Data</td>
<td>Mapping the Materials Base for REMADE</td>
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<td>Assessment of Opportunities and Technologies for Reducing Energy</td>
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<td>Consumption through Resource Recovery.</td>
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<td>Techno-economic Analysis Models and Tools</td>
<td>Systems Analysis for PET and Olefin Polymers in a Global Circular</td>
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<tr>
<td>Assessment</td>
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<td>Identifying strategies to maximize benefit of fiber recovery through</td>
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<td>Design for Re-X Methods and</td>
<td>Design for Remanufacturing</td>
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<td>Data-Driven Design Decision Support for Re-X of High-Value</td>
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<td>High-Impact Design for Re-X</td>
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<td>Components in Industrial and Agricultural Equipment</td>
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<td>Application Domains</td>
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<tr>
<td>Manufacturing and Process</td>
<td>Development of a Castable High Strength Secondary Aluminum Alloy from Recycled Wrought Aluminum Scrap</td>
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<td>Control Technologies</td>
<td>Cross-Industry Utilization of Ground Tire Rubber for Energy Efficient Pavements</td>
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<td>Characterization, Qualification,</td>
<td>Increasing melt efficiency and secondary alloy usage in aluminum die casting</td>
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<td>Simulation Technologies</td>
<td>Nondestructive Evaluation of In-flight Particle Dynamics and Intrinsic</td>
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<td>Epoxy/Silicon Potting Material Removal for Greater Recovery of Circuit</td>
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<td>High Speed Laser Cladding for Hard Surface Replacement</td>
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### Technologies and Tools to Increase Collection and Recovery
- Evaluation of logistics systems for collection-preprocessing and production of secondary feedstocks from e-waste
- Assessment of the impact of Single Stream Recycling on Paper Contamination in Recovery Facilities and Paper Mills

### Recycling & Recovery
- Rapid Sorting of Scrap Metals with Solid State Device
- Scalable High Shear Catalyzed Depolymerization of Multilayer
- Determining Material, Environmental and Economic Efficiency of Sorting and Recycling Mixed Flexible Packaging and Plastic Wrap
- Material Characterizations and Sorting Specifications That Can Allow the Development of Advanced Tire Constructions with High Incorporation of Recovered Rubber Materials
- Reinforced Recycled Polymer Composites (RRPC)

### Chemical and Solvent-Based Recycling Technologies
- Chemical Recycling of Mixed Plastics and Valuable Metals in the Electronic Waste Using Solvent-Based Processing
- Pushing the State of the Art in Steel Recycling through Innovation in Scrap Sorting and Impurity Removal
- Demineralization of Carbon Black Derived from End-of-Life Tires
- New Approaches to Improve Deinking Flotation to Increase the Availability of High-Quality, Low-Cost Recycle Paper Fibers

Denotes Technical Thrust not addressed in First Project Call

Projects listed in blue denote projects selected for negotiation from the 2nd Project call