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.
June 11-12, 2019

Dr. Nabil Nasr

REMADE INSTITUTE

Sustainable Manufacturing Innovation Alliance
Award Number DE-EE0007897
1/13/2017 – 12/31/2021

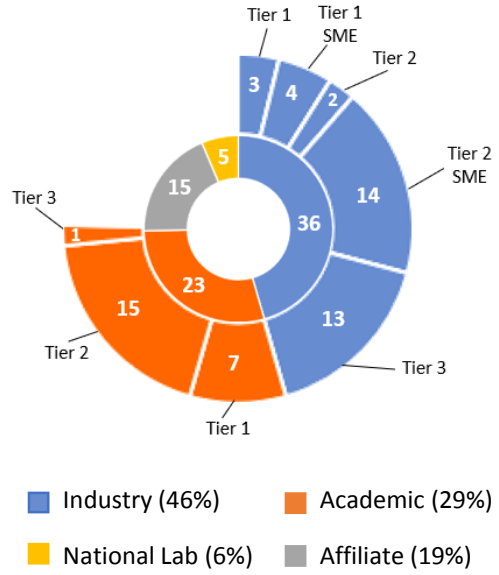
Institute Overview

Schedule

- REMADE award issued Jan 2017 & funding released in May 2017
- Projected end date December 2021
- BP1 – May ‘17- Mar ‘18.
- 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

Membership

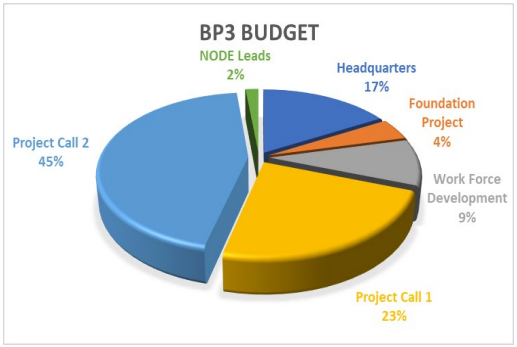
- 79 Members as of 5/16/19
  - 36 Industry
  - 23 Academic
  - 15 Affiliate
  - 5 National Labs
- 53% of industry members are small/ medium sized businesses
- 93% Retention Rate
  - 68 orgs have reached renewal period
  - 63 have confirmed renewal
- 6 organizations joined in Q1 2019



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

	FY 17 Costs	FY 18 Costs	FY19 Costs	FY20-FY 21 Costs
DOE Funded	$361K	$1.5M	$3.4M	$64.7M
Cost Share	$44K	$2.2M	$3.4M	$64.3M



Challenges

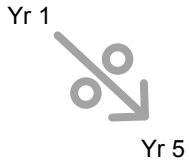
- **Identifying Responsive Design for Re-X Projects** – First two project calls resulted in three Design for Re-X projects.
- **Timely RFP Development** – Have modified process for developing RFPs and the structure of Technology Roadmap to address this
- **Project Negotiation** – Delays negotiating/launching 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)

 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.

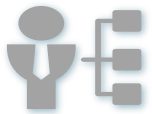
Project Objective:
Reduce embodied energy and carbon emissions through early stage applied research & development

REMADE STRATEGIC GOALS



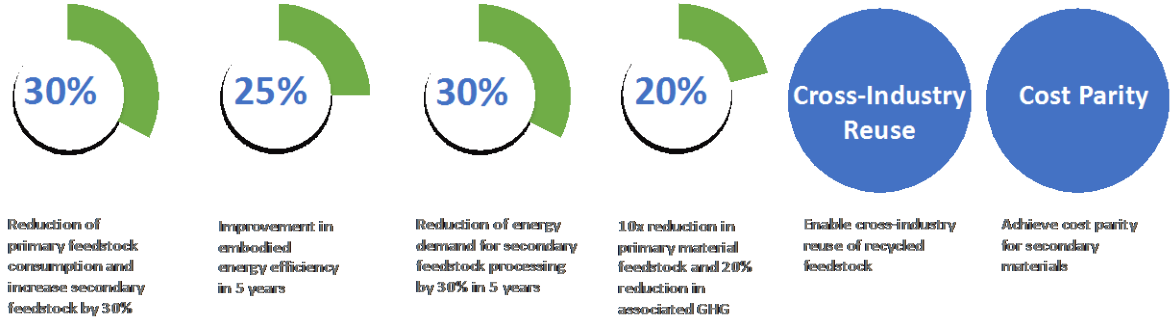
Enable **greater utilization of secondary feedstocks** which require less energy to produce for key materials

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)*



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

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Why REMADE?

Global sales of plastic bottles
~ 1 million/minute

Plastic Recycling Rate dropped
to 4.4% in 2018

U.S. generates 9.4M tons of
e-waste per year

Represents 2% of MSW
& growing at 4% annually

U.S. Production of
Aluminum & Steel

Accounts for ~10% of U.S.
Manufacturing Energy Use

China consumes 55%
of global paper scrap

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***

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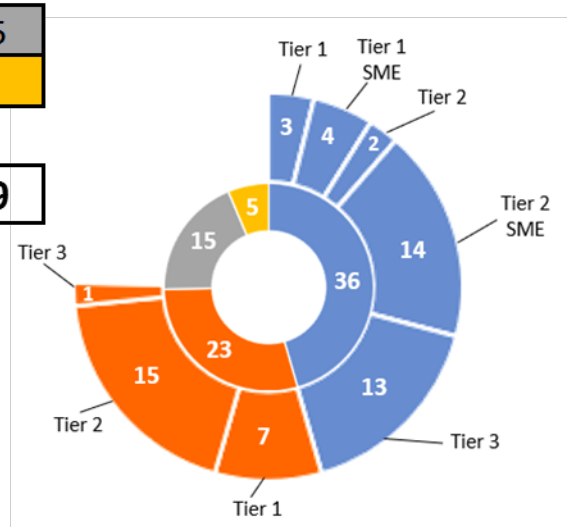
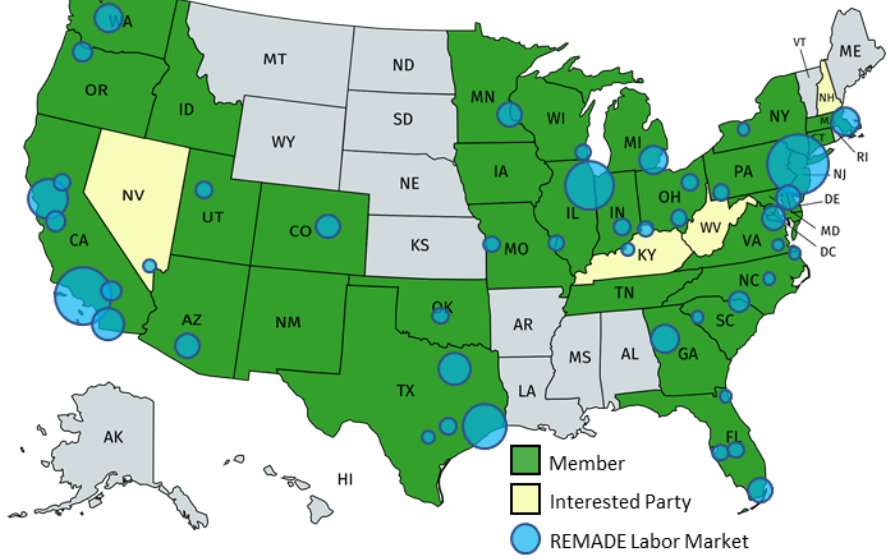
REMADE Members (5/16/2019)

- 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

	TOTAL	Tier 1		Tier 2		Tier 3
Industry	36	7		16		13
		Large	SME	Large	SME	
		3	4	2	14	
Academic	23	7		15		1
Affiliate	15					
National Lab	5					
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

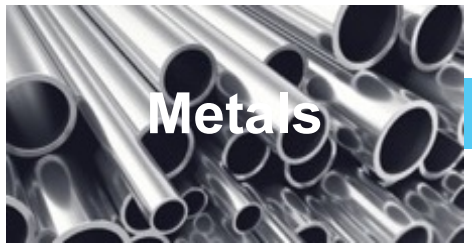
Technologies to reduce in-process losses, reuse scrap materials, and utilize secondary feedstock in manufacturing

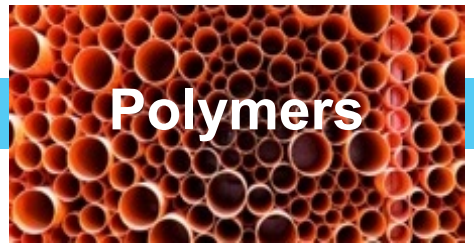
Remanufacturing/ EOL Reuse

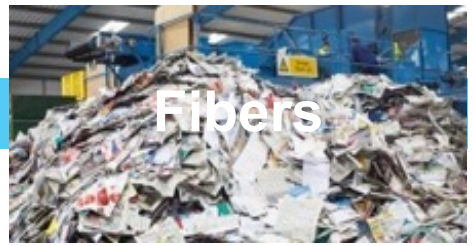
Efficient and cost effective technologies for cleaning component restoration, condition assessment, and reverse logistics

Recycling and Recovery

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







Technology Innovation – Organized by Stages of the Material Lifecyle

MATERIAL CLASSES

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Project Portfolio

31 Projects

45 Collaborating Organizations

$15 Million Project Value

13 Projects
$7.7M Project Value

Recycling and Recovery

7 Projects
$2.3M Project Value

Remanufacturing/ EOL Reuse

5 Projects
$2.6M Project Value

Systems Analysis and Integration

3 Projects
$0.6M Project Value

Design for Re-X*

3 Projects
$1.7M Project Value

Manufacturing Materials Optimization

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Technical Approach – Identifying Research Activities that Enable REMADE to meet its TPMs

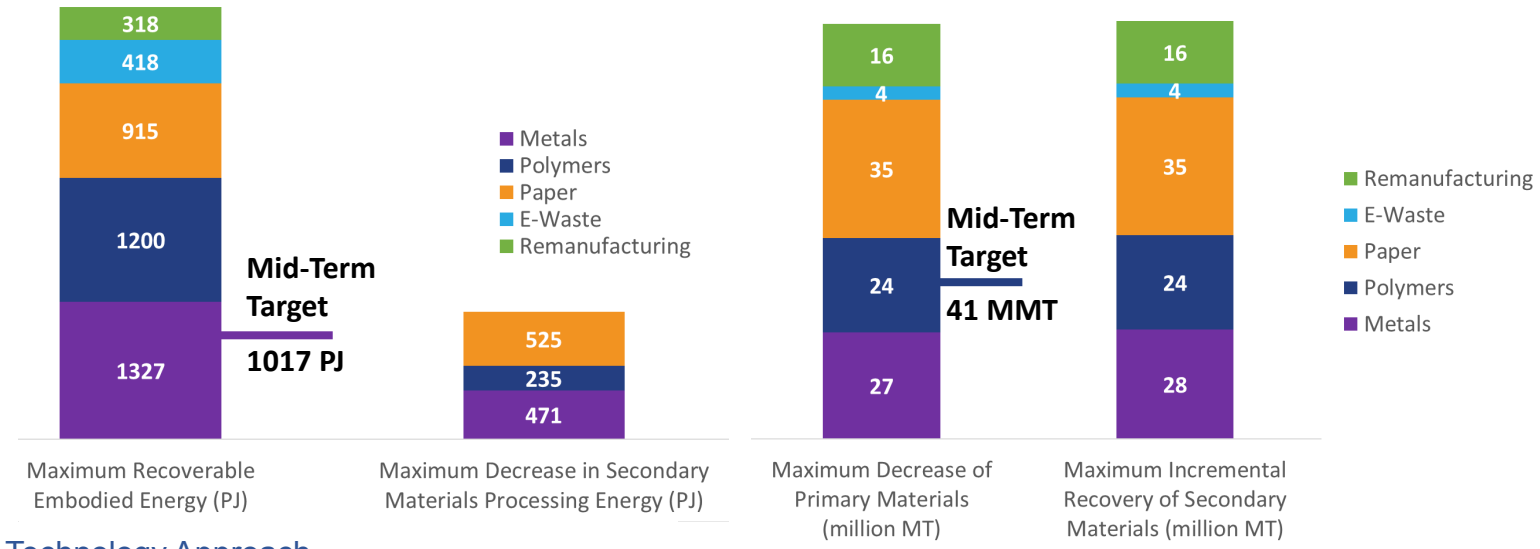
Focus of BP2 Technology Roadmap Update

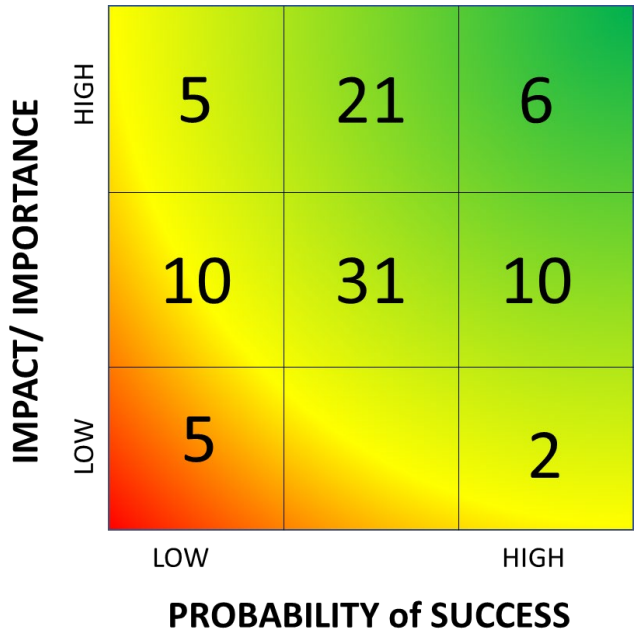
- Conduct industry interview to refine roadmap content
- Develop strategy for meeting the TPMs based on energy/emissions/material impacts for mat'l classes
- Reorganize roadmap by Thrust Areas for each node
- Develop dashboard to strategically allocate resources

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





Technical Approach - Material Classes Addressed & Project Impacts by Thrust Area

Node Node	Thrust Area	1st RFP	2nd RFP	Material Classes					Project Impacts		
				Metals	Polymers	E-waste	Fibers	Others	Energy Savings (PJ)	Primary FS Savings (MMT)	Secondary FS Incr (MMT)
Systems Analysis and Integration	Material Flow, Lifecycle Analysis, and Systems Analysis Methods, Tools, and Data	3		2	3	2	2		62	-1.8	+1.8
	Techno-economic Analysis Models and Tools		2				2		TBD	TBD	TBD
Design for Re-X*	Design for Re-X Metrics & Assessment Frameworks	1				1			TBD	TBD	TBD
	Design for Re-X Methods and Tools		2	2	1	1			48	-0.54	TBD
	High-impact Design for Re-X Application Domains										
Manufacturing Materials Optimization	Manufacturing and Process Control		2	1				1	10.7	-0.18	0.18
	Characterization, Qualification & Simulation	1		1					30	-0.16	0.12
Remanufacturing/ EOL Reuse	Robust Non-destructive Inspection/ Evaluation Technologies	2		2					TBD	TBD	TBD
	Remanufacturing Analysis Tools & Methods	3		2		1			42	TBD	TBD
	Low-cost Component Repair Technologies and Restoration Methods	1	1	1		1			43.3	-0.05	
Recycling and Recovery	Technologies/Tools to Increase Collection & Recovery	2				1	1		317	-9.9	9.9
	Mechanical Recycling Technologies for Sorting, Separating, and Liberating Materials	3	3	1	3	1		1	130	-3.3	3.3
	Chemical and Solvent-Based Recycling & Separation Technologies		1		1	1			16.5	-0.34	0.34
	Characterization, Cleaning & Purification	3	1	3			1	1	87	-2.3	1.5
	TOTALS	34		15	8	9	6	3	787	18.6	17.1

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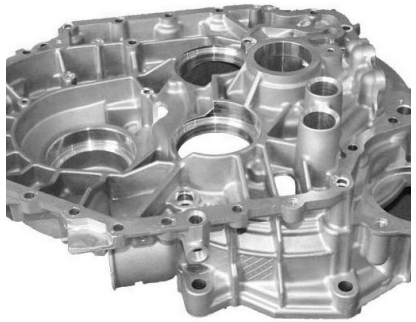
Delivering Impact Across Entire Material Lifecycle

Solar Cell Performance & Lifecycle Mgmt (Design)

Balance Performance, Total Cost of Ownership, & Embodied Energy

25% Reduction in Embodied Energy

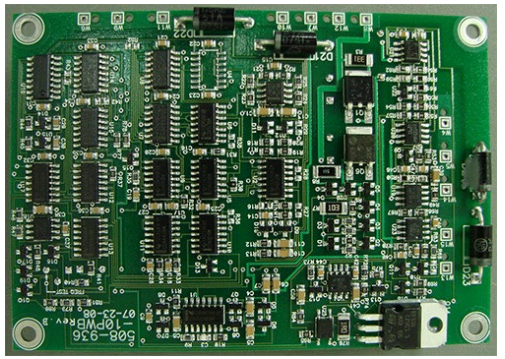
Aluminum Die Casting (Manufacturing)



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)

Steve Smith/FutureMark Paper

Develop Novel Deinking Technologies for Water Soluble Inks

Recover 0.87 MMT of Paper and Reduce Energy Use by 42 PJ

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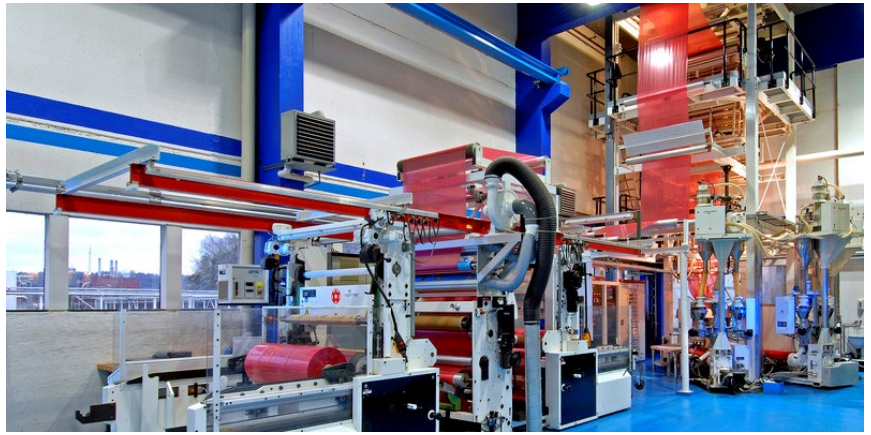
Addressing Entire Value Stream for Film & Flexibles



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

Unilever · Michigan Technological University · RRS · UMASS LOWELL · SUNNKING We Rule Electronics Recycling · MICHIGAN STATE UNIVERSITY · INL Idaho National Laboratory · American Chemistry Council · NREL National Renewable Energy Laboratory

Design & Systems Analysis + Collection → Sorting → Liberation/ Sizing → Cleaning → Separation of Mixed Materials → Purification → Reprocessing

✓ ✓ ✓ ✓

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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

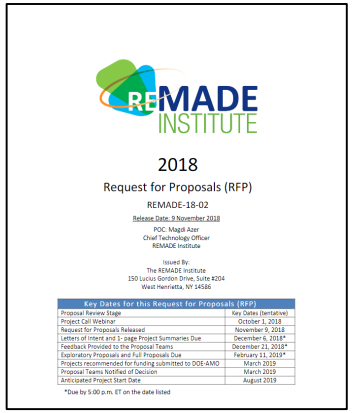
- Technology Roadmap updated (May ‘19)
- Reorganized roadmap by Thrusts Areas and developed Dashboard to strategically assess portfolio
- Update/alignment guided by member interviews and TLC analysis of which material classes and tech dev opportunities will deliver the greatest impact toward the TPMs

✓ 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 INSTITUTE

2018

Request for Proposals (RFP)

REMADE-18-02

Release Date: 9 November 2018

POC: Magdi Aser
Chief Technology Officer
REMADE Institute

Issued By:
The REMADE Institute
150 Lucius Gordon Drive, Suite #204
West Henrietta, NY 14586

Key Dates for this Request for Proposals (RFP)	
Proposal Review Stage	Key Dates (tentative)
Project Call Webinar	October 1, 2018
Request for Proposals Released	November 9, 2018
Letters of Intent and 1- page Project Summaries Due	December 6, 2018*
Feedback Provided to the Proposal Teams	December 21, 2018*
Exploratory Proposals and Full Proposals Due	February 11, 2019*
Projects recommended for funding submitted to DOE-AMO	March 2019
Proposal Teams Notified of Decision	March 2019
Anticipated Project Start Date	August 2019

*Due by 5:00 p.m. ET on the date listed

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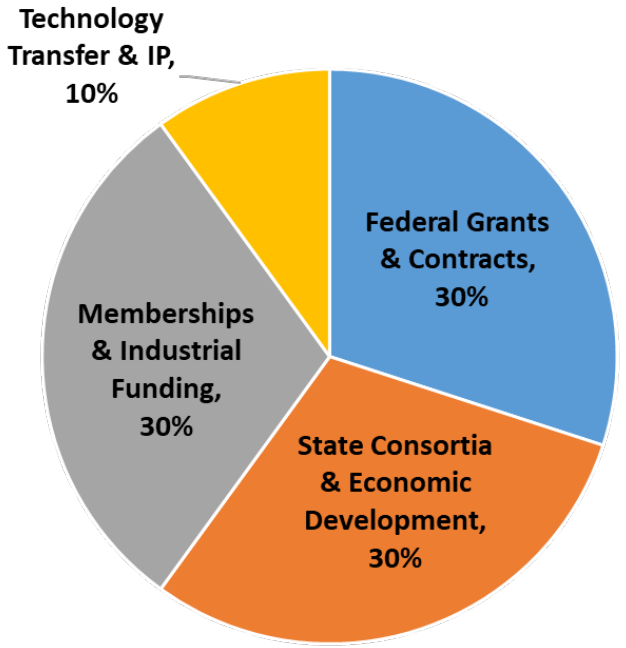
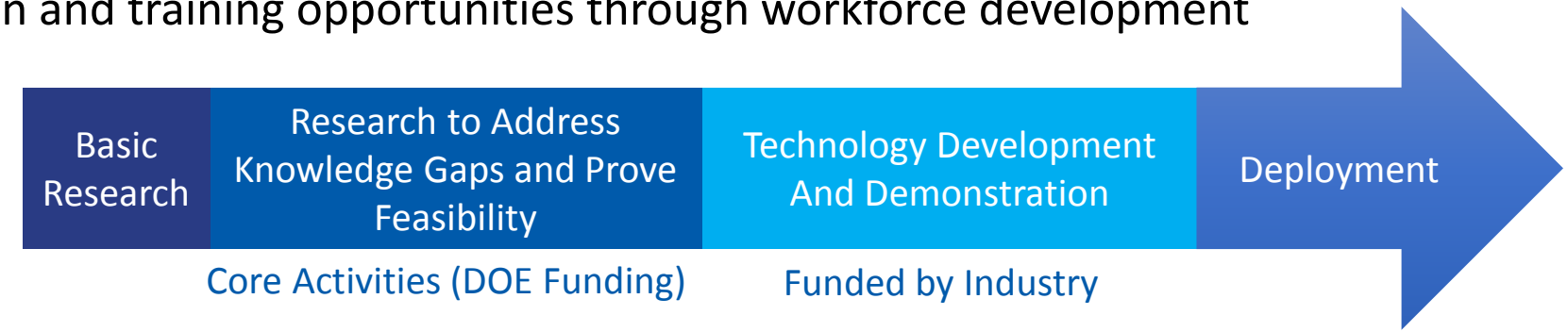
REMADE Transition – Road to Sustainment

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

Funding Diversification for Institute Self Sustainment





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Projects by Thrust Area

Node	Technical Thrust	REMADE Project
Systems Analysis	Material Flow, Lifecycle Analysis, and Systems Analysis Methods, Tools, and Data	Mapping the Materials Base for REMADE
		Assessment of Opportunities and Technologies for Reducing Energy Consumption through Resource Recovery.
		Systems Analysis for PET and Olefin Polymers in a Global Circular
	Techno-economic Analysis Models and Tools	A Dynamic Techno-economic Systems Modeling Framework for U.S.
		Identifying strategies to maximize benefit of fiber recovery through
Design for Re-X	Design for Re-X Metrics and Assessment	Development of an Industrially Relevant RE-SOLAR Design Framework
	Design for Re-X Methods and Tools	Design for Remanufacturing
		Data-Driven Design Decision Support for Re-X of High-Value Components in Industrial and Agricultural Equipment
	High-impact Design for Re-X Application Domains	
Mfg Materials	Manufacturing and Process Control Technologies	Development of a Castable High Strength Secondary Aluminum Alloy from Recycled Wrought Aluminum Scrap
		Cross-Industry Utilization of Ground Tire Rubber for Energy Efficient Pavements
	Characterization, Qualification, and Simulation Technologies	Increasing melt efficiency and secondary alloy usage in aluminum die casting
Remanufacturing and End-of-life Reuse	Non-destructive Inspection/Evaluation Technologies	Nondestructive Evaluation of In-flight Particle Dynamics and Intrinsic Properties for Thermal Spray Repairs
		Non-Destructive In-process Assessment of Thermal Spray Repairs
	Remanufacturing Analysis Tools and Methods	Condition Assessment of Used Electronics
		Remaining Life Determination
		Quantitative Non-Destructive Evaluation of Fatigue Damage Based on
	Low-cost Component Repair Technologies and Restoration Methods	Epoxy/Silicon Potting Material Removal for Greater Recovery of Circuit
		High Speed Laser Cladding for Hard Surface Replacement

Recycling & Recovery	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
	Mechanical Recycling Technologies for Sorting, Separating, and Liberating Materials	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)
		Low-Cost, High-Value Metal Recovery from Electronic Waste to Increase Recycling and Reduce Environmental Impact
	Chemical and Solvent-Based Recycling Technologies	Chemical Recycling of Mixed Plastics and Valuable Metals in the Electronic Waste Using Solvent-Based Processing
	Characterization, Cleaning, and Purification Technologies	Pushing the State of the Art in Steel Recycling through Innovation in Scrap Sorting and Impurity Removal
		Removing Trace Contaminants in Recycled Metals
		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