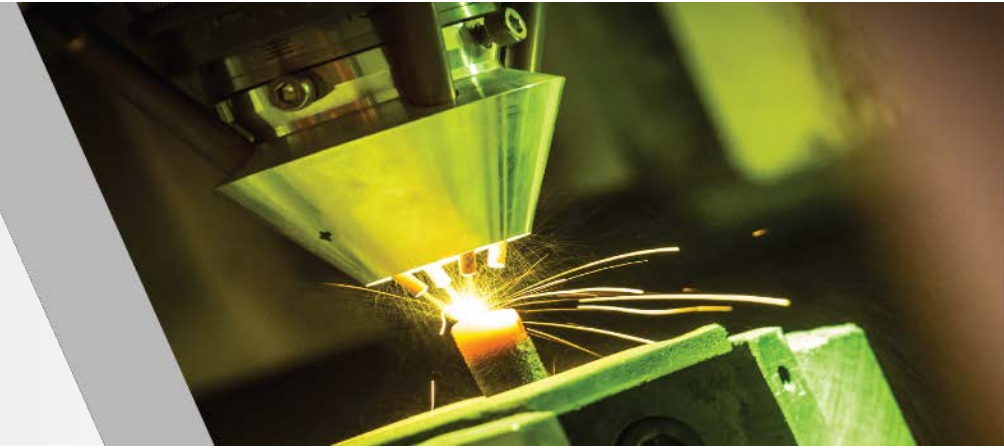




Clean Energy, Innovation & Sustainability
MANUFACTURING A SUSTAINABLE FUTURE



U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
July 17-19, 2018

Dr. Nabil Nasr

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
- Successfully completed BP1 Go/No-Go Milestones Mar 31, 2018 – required a 3 month, no cost extension

TECHNOLOGY

- Roadmapping workshop - 9/17
- Draft roadmap released – 11/17
- First project call released - 1/18
- Foundational project awards - 2/18

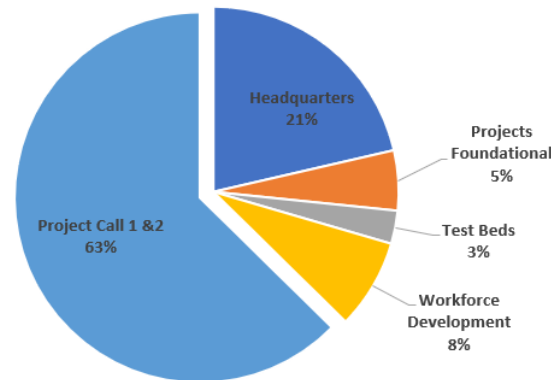
OPERATIONS

- Leadership team in place - 9/17
- Membership agreement - 9/17
- Financial accounting system - 9/17

Budget

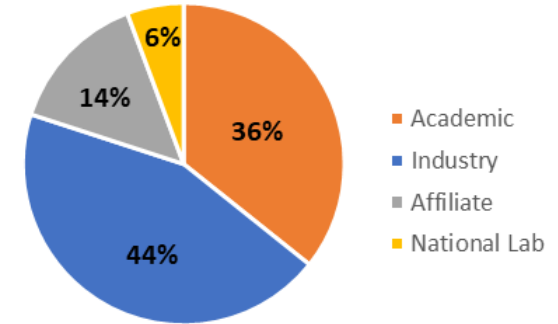
- \$140M award, \$70M federal / \$70 match
- Received \$10M from New York State to support cost share
- Institute is meeting the 1:1 cost share requirement
- Fiscal year 2017 audit successfully completed
- Receivables and payables current, including annual membership dues

	FY 17 Costs	FY 18 Costs	FY 19- FY 21 Costs
DOE Funded	361K	976K	\$66M
Cost Share	43K	1.6M	\$68M



Membership

- 71 Members as of 6/14/18
 - 31 Industry, 25 academic, 10 affiliate, and 4 national labs
- 44% of membership is industry
 - 55% of industry members are small/medium sized businesses
- Membership is geographically dispersed across the U.S.
- Retention - first membership renewal is due Oct 2018



Challenges


- Early delays releasing the first project call and developing the technology roadmap required a 3 month no-cost extension to BP1
- Staffing - difficulty identifying and attracting qualified candidates remains a challenge, especially technical project managers
- Initiating projects – long cycle time from proposal submission to project start within the cooperative agreement structure
- Cash Management – reimbursement basis vs advance payment is challenging for an independent institute

Project Objective


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

REMADE STRATEGIC GOALS

Yr 1
Yr 5

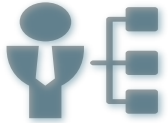


Enable **greater utilization of secondary feedstocks** which require less energy to produce for key materials



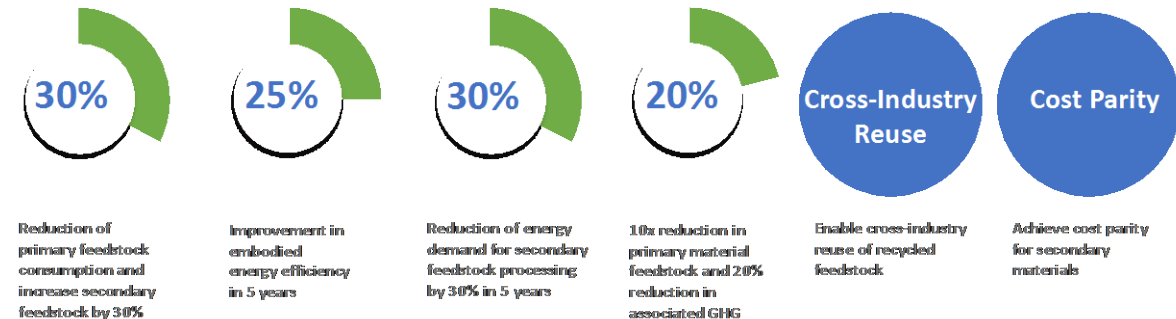
Reduce primary materials consumption (and energy lost when they are landfilled) while achieving better than cost and energy parity for key secondary materials

Secondary Feedstock Primary Feedstock



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)*



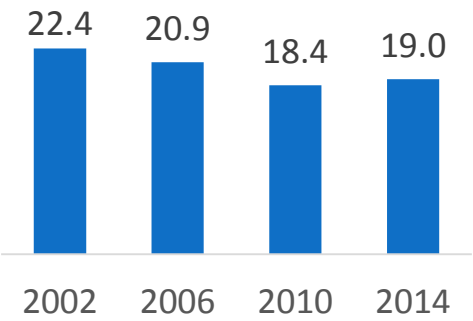
REMADE Institute is aligned to directly support the AMO mission and strategic goals

* Address Technical Targets 14.1, 14.2, and 14/3 from AMO MYPP

Technical Innovation

TECHNOLOGY LANDSCAPE CHALLENGING

Energy consumption large & increasing



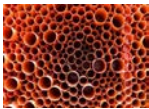
U.S. Manufacturing Energy Consumption (Quads), 2002-2014

Barriers often Material Specific



Aluminum/Steel

- High-embodied energy
- Trace material contamination



Polymers

- Low fuel price a barrier to cost parity
- Flexible packaging hard to sort/recycle



Fibers

- Contamination from glass/stickies
- Scrap market volatility

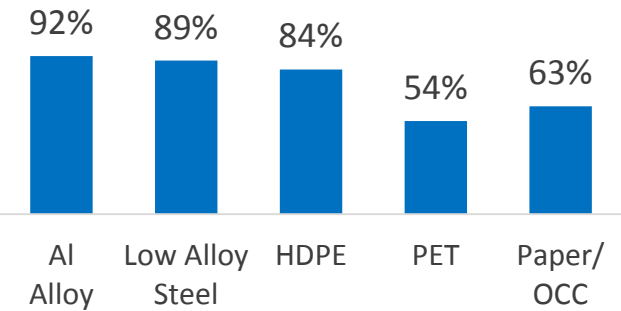


E-waste

- Lifespan of electronics shrinking
- Logistics/economies of scale

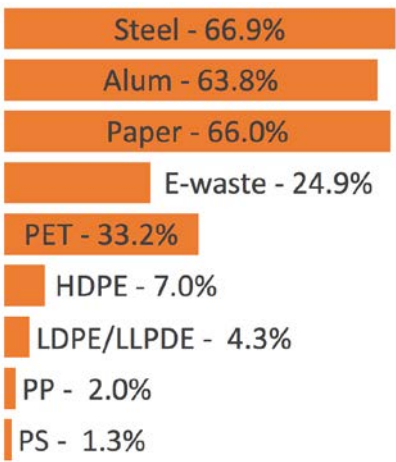
OPPORTUNITIES ABOUND

Increase Secondary Feedstock Use



% Embodied-Energy Savings when using secondary feedstock

REMADE Goals Aligned to Market Needs



Recycling Rate for Different REMADE-relevant Materials

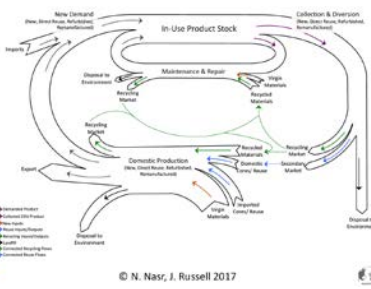


China Scrap Import Ban

WELL STRUCTURED TO SUCCEED

Systems Analysis and Integration

Cross-cutting opportunities
Technoeconomic analysis
Impact of changing demand patterns & new technology
Provide member with tools to calculate assess benefits



Balancing Risk/Reward in Portfolio





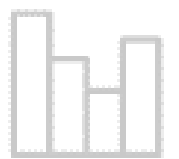


Each RFP includes funds to pursue Exploratory Proposals
Encourages broader participation

Testbeds Facilitate Validation/Scale-Up



11 Geographically-dispersed Facilities

Technical Innovation – Overcoming the Technical & Economic Barriers

TECHNOLOGY FOCUS AREAS (NODES)	CONTRIBUTION TO REMADE METRICS	TECHNICAL & ECONOMIC BARRIERS
 SYSTEM ANALYSIS AND INTEGRATION Data collection, standardization, metrics, and tools for understanding material flow	Increase secondary feedstock (SF) availability, Embodied-energy (EE) decreases as SF increases	LCA/MFA methods don't consider market & economic issues or capture system interactions. Tools for tracking materials flows insufficient*.
 DESIGN FOR RE-X¹ Design tools to improve material utilization and reuse at End-of-Life (EOL)	Improve ability to disassemble, recover, recycle, and remanufacture at end-of-life	Design specs/tools don't address Re-X factors or consider impact of design trade-offs on EOL*.
 MFG MATERIALS OPTIMIZATION Improve material efficiency* in a manufacturing facility; reduce in-process losses & efficiently reuse scrap	Reuse in-plant scrap, reduce process losses, and use SFs w/o loss of properties or performance	Greater property variation & higher losses with SFs. Typically don't reuse in-plant scrap*.
 REMANUFACTURING AND EOL² REUSE Technologies for cleaning, component restoration, condition assessment, and reverse logistics	Reduce primary feedstocks through increased reuse, EE decreases as reuse increases	Difficult to predict remaining life/residual value. Labor/mfg costs often cost-prohibitive.
 RECYCLING & RECOVERY Rapid gathering, identification, sorting, separation, contaminant removal, reprocessing and disposal	Increase secondary feedstock (SF) availability, Embodied-energy (EE) decreases as SF increases	SFs more expensive than PFs. Sorting/separation & cleaning/characterization methods ineffective. Reverse logistics

¹ Re-X refers to recovery, reuse, remanufacturing, and recycling

² EOL refers to End-of-life

* Challenges/barriers identified in AMO MYPP

Technical Approach – Start-up

Foundational Projects

- 9 Projects Identified to start in first 6 months
- Proposals due Oct '17/Reviews held Nov '17
- 3 Recycling & Recovery proposals selected

Assessment of the Impact of Single Stream Recycling (SSR) on Paper (Active)

- Energy Savings – 2120 MMBtu per 1M Metric Tons
- Cost Savings - \$10M per 1M Metric Tons (MT)

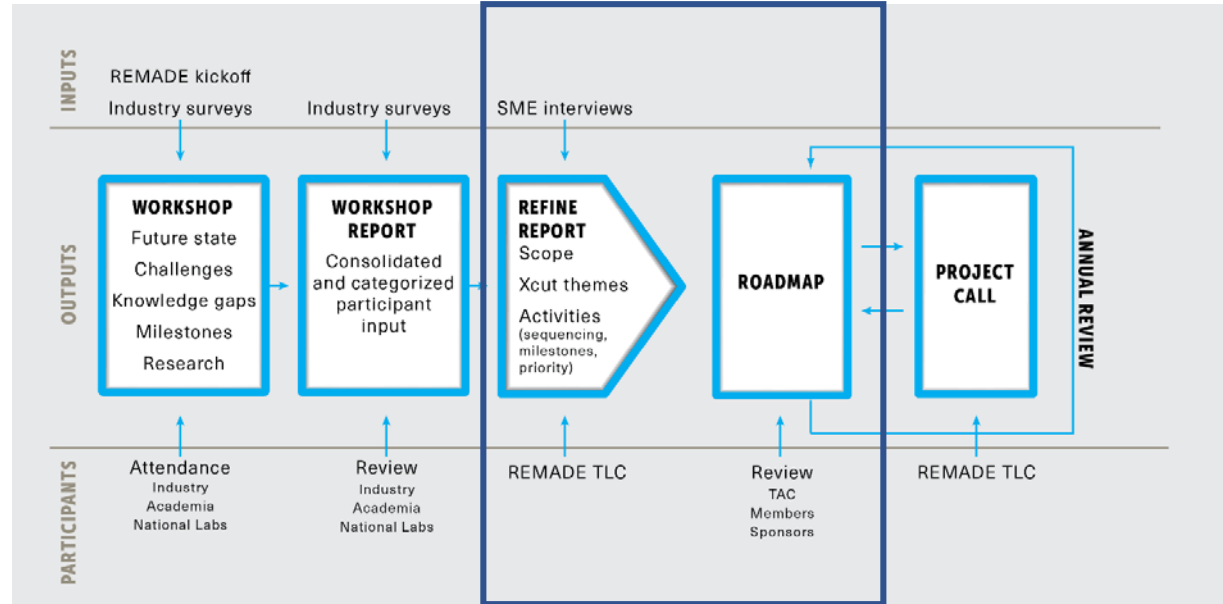
Advanced Solid State Eddy-Current Sorting of Light Metals and Alloys (In Negotiation)

- Increase recovery of scrap Al from fine Zorba > 90% while maintaining 90% grade or better.
- Increase throughput to 1 MT/hr. with path to 2-4 MT/hr.
- Net cost to operate ~ \$1/ton vs \$70/ton to clean, process, dry, and transport prior to recycling.

Selective Recovery of Polymers and Residual Metals from E-waste (In Negotiation)

- Recover 3.5 MT of ABS, PS, ABS/PC alloy, and PC from obsolete electronics at “better than feedstock quality”.
- Reduce energy consumption by 350 TBtu/yr & GHG emissions by 17.4 MTCO₂e. \$800M opportunity

Technology Roadmap Process



- Workshop held Sep 18-20, 2017
- 157 Survey participants and 90 workshop participants
- 7 interviews with pulp/paper industry after workshop

Development of the Roadmap Shaped 1st Project Call

Technical Approach - 1st Request for Proposal (RFP) & BP2 Roadmap

Highlights

- 16 Topics across 5 Nodes/4 Material Classes
- REMADE funds available - \$6M, split into
- Exploratory (\$1M) & Full Proposals (\$5M)

Exploratory Projects (12 months or less)

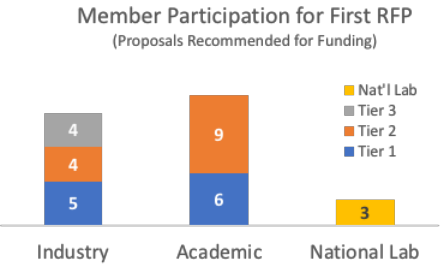
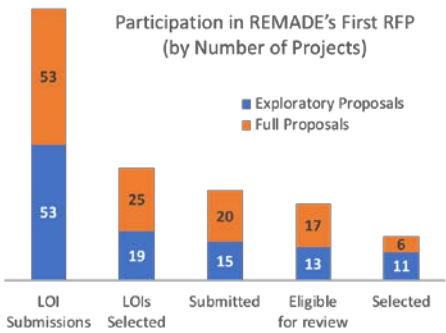
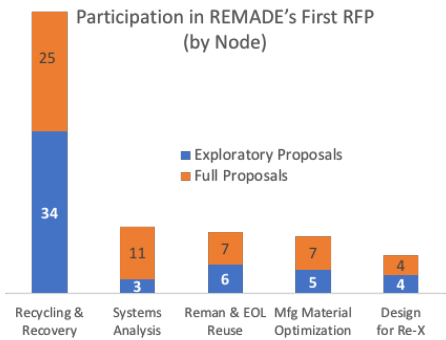
- REMADE Funds - \$100K Max & ~10 Projects
- Seed funds to demo proof-of-concept (POC) and reduce uncertainty for high-risk/high-reward approaches.
- Expected outcome - Demonstrate POC and reduce uncertainty

Full Proposals (12-24 months)

- REMADE Funds - \$500K Max & ~10 Projects
- Facilitate technology maturation where POC complete/ key uncertainties addressed
- Expected outcome - validation in a “lab” or “relevant” environment by project end

Robust Response to 1st RFP

(103 Project Summaries Submitted)



30 of 69 Members Engaged!

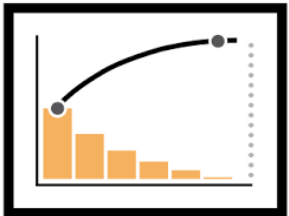
17 Projects Selected from 1st RFP

Key Risks/ Impacts Going Forward

- REMADE Topics Broad – Fail to achieve TPMs
- Global Scrap Market Volatility – Moving Target
- Member Retention – Coming up on Renewal

Mitigation Strategy – BP2 Roadmap Refresh

- Early BP2 milestones guide Roadmap refresh



ID Best Opportunities to meet REMADE TPMs



Interview Members to Confirm Their Priorities are in Roadmap

Results will shape the 2nd Project Call in July



Provide Guidance on how to calculate REMADE benefits



Develop analysis method and tool to calculate benefits

Tools To Help Members Better Measure Impact

Proposals Selected for Funding from First Project Call

Project Title	RFP Topic	Proposal Type	Total Project Cost
Systems Analysis for PET and Olefin Polymers in a Global Circular Economy	SA-1	Exp	\$ 188,500
Mapping the Materials Base for REMADE	SA-1	Full	\$ 570,022
Assessment of Opportunities and Technologies for Reducing Energy Consumption through Resource Recovery.	SA-1	Full	\$ 1,058,372
Development of an Industrially Relevant RE-SOLAR Design Framework	DE-1	Exp	\$ 200,000
Increasing melt efficiency and secondary alloy usage in aluminum die casting	MM-3	Full	\$ 850,000
Nondestructive Evaluation of In-flight Particle Dynamics and Intrinsic Properties for Thermal Spray Repairs	RM-3	Exp	\$ 200,000
Remaining Life Determination	RM-1	Exp	\$ 200,000
Non-Destructive In-process Assessment of Thermal Spray Repairs	RM-3	Exp	\$ 200,000
Quantitative Non-Destructive Evaluation of Fatigue Damage Based on Multi-Sensor Fusion	RM-1	Exp	\$ 200,000
Epoxy/Silicon Potting Material Removal for Greater Recovery of Circuit Boards	RM-2	Exp	\$ 399,980
Condition Assessment of Used Electronics	RM-1	Full	\$ 1,190,432
Development of New Cost-Effective Methods for Removing Trace Contaminants in Recycled Metals	RR-3	Exp	\$ 200,000
Pushing the State of the Art in Steel Recycling through Innovation in Scrap Sorting and Impurity Removal	RR-2	Exp	\$ 200,000
Determining Material, Environmental and Economic Efficiency of Sorting and Recycling Mixed Flexible Packaging and Plastic Wrap	RR-1	Full	\$ 2,876,780
Evaluation of logistics systems for collection- preprocessing and production of secondary feedstocks from e-waste	RR-1	Full	\$ 1,000,000
Demineralization of Carbon Black Derived from End-of-Life Tires	RR-6	Exp	\$ 199,017
Scalable High Shear Catalyzed Depolymerization of Multilayer Plastic Packaging	RR-5	Exp	\$ 189,912
Total Awarded			\$ 9,923,015

Contributions of the These Projects Toward Achieving REMADE Technical Performance Metrics (TPMs)

Material and Economic Impacts

Metals

- Aluminum die-casting - Double use of secondary feedstocks to 20% and reduce cost 15%, reduce melt loss by 85 million lbs.
- Al recycling – reduce primary mat'l use 600,000 metric tons
- Thermal Spray in reman – reduce energy consumption 50%
- Cast-iron cylinder heads – reduce primary mat'l 20-32%

Polymers

- Flexible packaging & plastic wrap – recycle 6 million lbs./yr through better optical sorting vs 11 million lbs. landfilled/yr.
- Carbon black recycling - recover 1.1 million tons for use as secondary feedstock

E-waste

- Recoverable solar Industry e-waste project to grow from \$19M (2016) to \$450M (2030)
- PCBs – Increase reuse yield in heavy equipment 25-35%.
Reduce material losses by 9 million metric tons through reuse and repair
- E-waste recycling – increase mat'l efficiency 10% through more effective logistics.

Energy and Emission Impacts

Metals

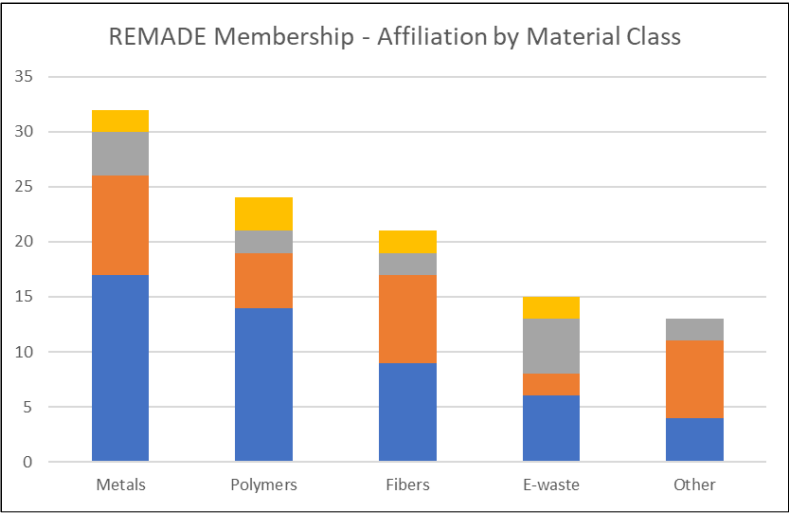
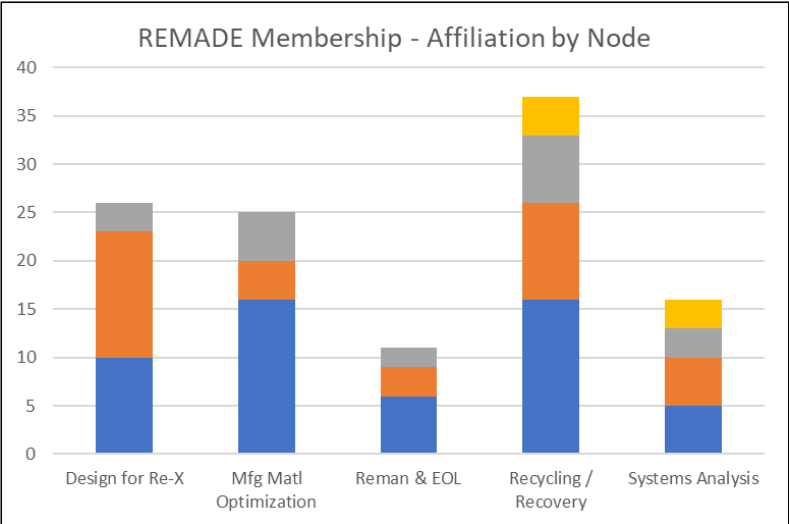
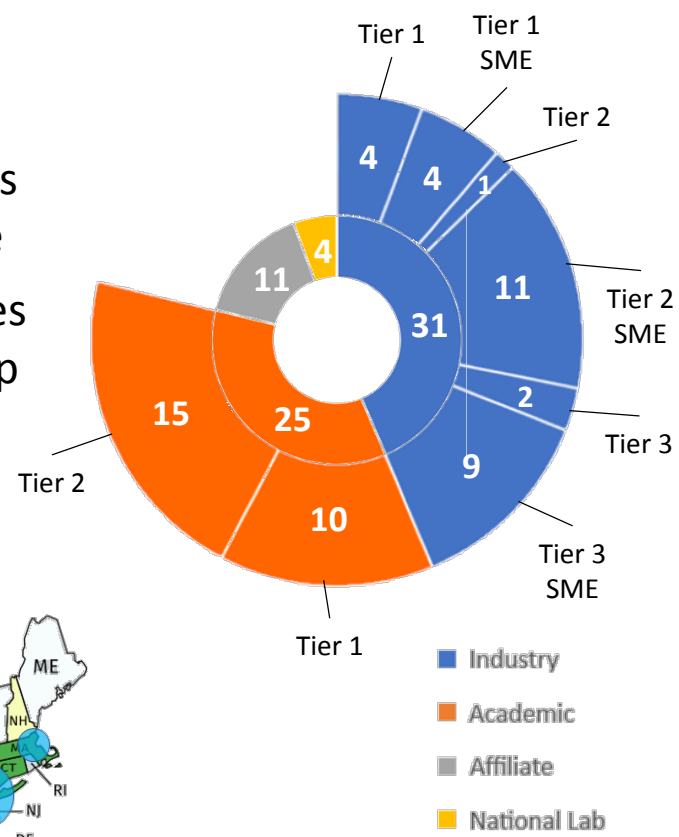
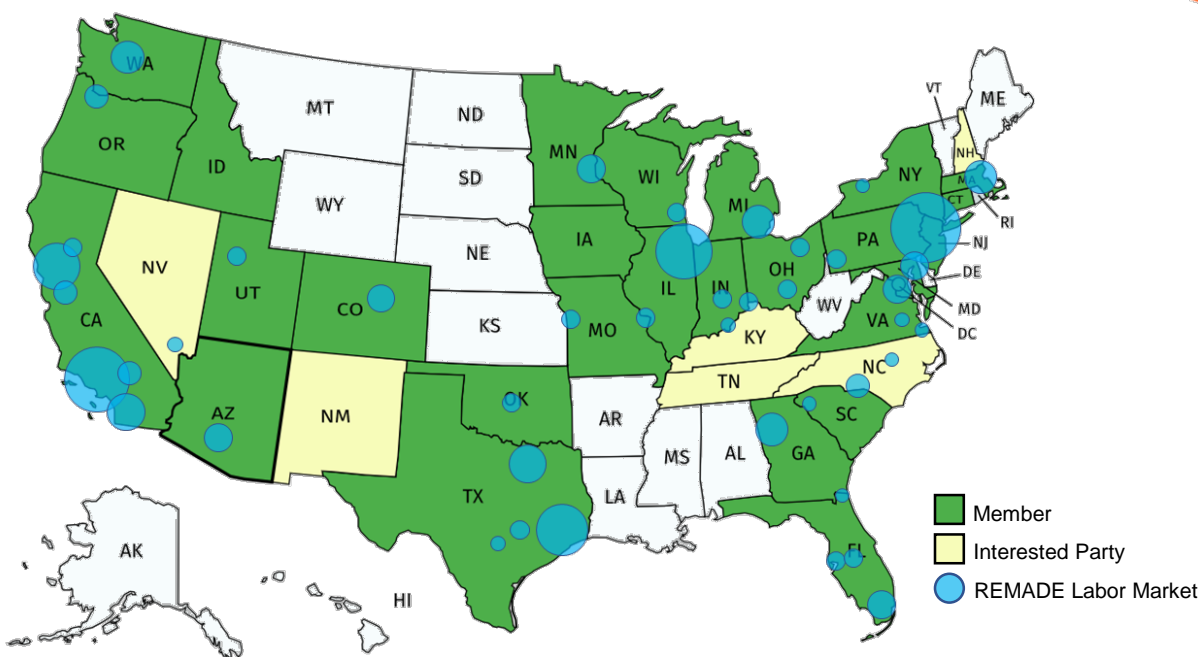
- Aluminum die-casting – Reduce embodied energy by 8.3×10^{12} BTU
- Al recycling – reduce energy consumption by 14 billion kWh
- Thermal Spray in reman – reduce energy consumption 50%
- Cast-iron cylinder head remanufacturing – reduce energy & emissions 20%

E-waste

- PCBs – reduce embodied-energy in remanufacturing 30%
- E-waste recycling – reduce energy and emissions by 20% and 10%, respectively

Membership Aligned with Technology Alignment

- Membership is geographically dispersed
- Workforce demand for REMADE occupations (blue circles) aligned to where members are
- The five focus areas and four material classes are well represented by current membership
- Membership composition supports the mission and goals of the Institute



Results and Accomplishments

✓ Projects

- Three quick start / foundational projects awarded in Jan '18
- 1st Institute Project Call held and 17 projects awarded in June '18
- 2nd Project Call planning underway, with anticipated release JAug '18

✓ Technology Roadmap

- Membership input guided roadmap creation – 90 participants at the 3-day roadmap workshop
- Tools created to calculate energy savings
- BP2 roadmap update/alignment being guided by member interviews and TLC analysis of which material classes and tech dev opportunities will deliver the greatest impact toward the TPMs

✓ Membership

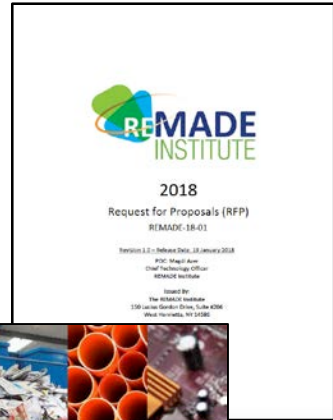
- Growing Membership – Currently 71 Members

✓ Education and Workforce Development

- Member steering committee formed, plan developed & partnerships created to drive initiatives
- REMADE occupations and labor analysis completed
- Hosted two Thought Leadership webinars – Materials Disruption (Apr) & Global Recycling (Jun)

✓ Operations

- Established an independent, not for profit organization
- Legal, Finance, HR, Membership, Marketing, & Technology processes implemented
- Governance Committee (GC) and two member-led committees created and operating
- Successfully completed BP1 Go/No-Go Milestones (3 month extension)



Thought Leadership Webinar Series

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

