Better Buildings® U.S. DEPARTMENT OF ENERGY

Better Plants® U.S. DEPARTMENT OF ENERGY

Waste Reduction Pilot

Q4 Webinar, E-Waste

Thursday November 19, 2020

2 – 3 pm EST

Waste Reduction Pilot

Quarterly calls: What do we hope to get out of them?

- Spotlight Leadership – Share Best Practices
- Present Valuable Resources
- Provide a Forum to Share Challenges and Opportunities

Hannah Debelius

ORISE Fellow, DOE

Andrea Doukakis

Consultant, RE Tech Advisors

Agenda

1. Introduction & Waste Reduction Pilot Program Updates
2. Jim Henry – Global Data Center Compliance Manager, Iron Mountain Data Centers
3. Ed Daniels – Project Engineer, REMADE Institute
4. Q&A and Resources

Thank you, Waste Pilot Participants

Industrial

- Armstrong Flooring
- AstraZeneca
- Bristol-Myers Squibb
- Cooper Standard
- Cummins, Inc.
- Electrolux
- Flowers Foods
- FMC Chemicals
- General Motors
- Gibraltar Industries
- Graham Packaging
- HARBEC
- Honda North America
- Johnson Controls
- LBNL
- Lockheed Martin

Industrial

- Los Angeles Department of Water and Power
- Martin Guitar
- Nissan North America
- NSK Americas
- PaperWorks Industries
- PPC Online
- Schneider Electric
- Steelcase, Inc.
- Sugar Creek Packing Co.
- United Technologies Corporation (UTC)
- Valmont Industries
- Volvo Group North America

Commercial

- Bozzuto Management Company
- City of Reno, NV
- CommonWealth Partners
- The Hartford Financial Services Group
- Jamestown, LP
- Lawrence Berkeley National Laboratory
- Montefiore Medical Center
- New Bedford Housing Authority
- Parkway
- Shorenstein Properties, LLC
- Sprint
- Tenderloin Neighborhood Development Corp.
- The Tower Companies
- USAA Real Estate
- UW Health
- The West Palm Beach VA Medical Center*

*(part of the U.S. Dept. of Veterans Affairs' Sunshine Healthcare Network)

Welcome New Partners to the Pilot!

Industrial

HONDA
The Power of Dreams

GRAHAM PACKAGING COMPANY

Cummins

LOCKHEED MARTIN

GIBRALTAR INDUSTRIES

CooperStandard
PASSION FOR PERFORMANCE

valmont

Commercial

FOUNDATION COMMUNITIES

Montefiore

BOZZUTO

USAA REAL ESTATE

BIGGEST LITTLE CITY IN THE WORLD
CITY OF RENO

Waste Pilot Team

DOE

- Robert Bruce Lung, Senior Technical Advisor, BGS LLC, AMO
- Eli Levine, AMO
- Ethan Rogers, Fellow, AMO
- Hannah Debelius, ORISE Fellow, BTO

ICF

- Clifton Yin, embedded in AMO
- Kate Rubin
- Zach Abrams

RE Tech Advisors

- Andrea Doukakis

Program Updates

Summit 2021 – Please send topic or speaker ideas to Hannah Debelius or Bruce Lung

Next quarterly call in **February –** Please send topic or speaker ideas to Hannah or Bruce

Data collection season is coming! 2020 data due March 1st

Monthly email bulletins and other resources on our home page

Working Groups Update

Plastics

- Focused on plastic reduction, recycling, and closing the loop
- 2nd call held on Oct 22 and featured two industrial speakers. Reach out to Bruce if you'd like more information

Outreach & Engagement

- Focused on outreach, education, and engagement of building occupants for waste reduction and diversion
- 1st call held on Nov 9th. Reach out to Andrea if you are interested in participating

Today's Presenters

Jim Henry
Iron Mountain Data Centers

Ed Daniels
REMADE Institute

Jim Henry

Global Data Center Compliance Manager,
Iron Mountain Data Centers

Iron Mountain Data Centers

E-Waste, and Solutions to one of IT's Largest Waste Streams

Jim Henry, CISA
Manager, Global Compliance

IRON MOUNTAIN®

So, what’s a colocation data center?

- Whether you know it or not, you use (and most other folks) a data center ***every day***
- Industries include: streaming, gaming, banking, social media, government services, healthcare, and disaster recovery
- Colocation data centers contain servers that belong to everyone else, except the provider!
- All IT gear, has an end of life (EoL)

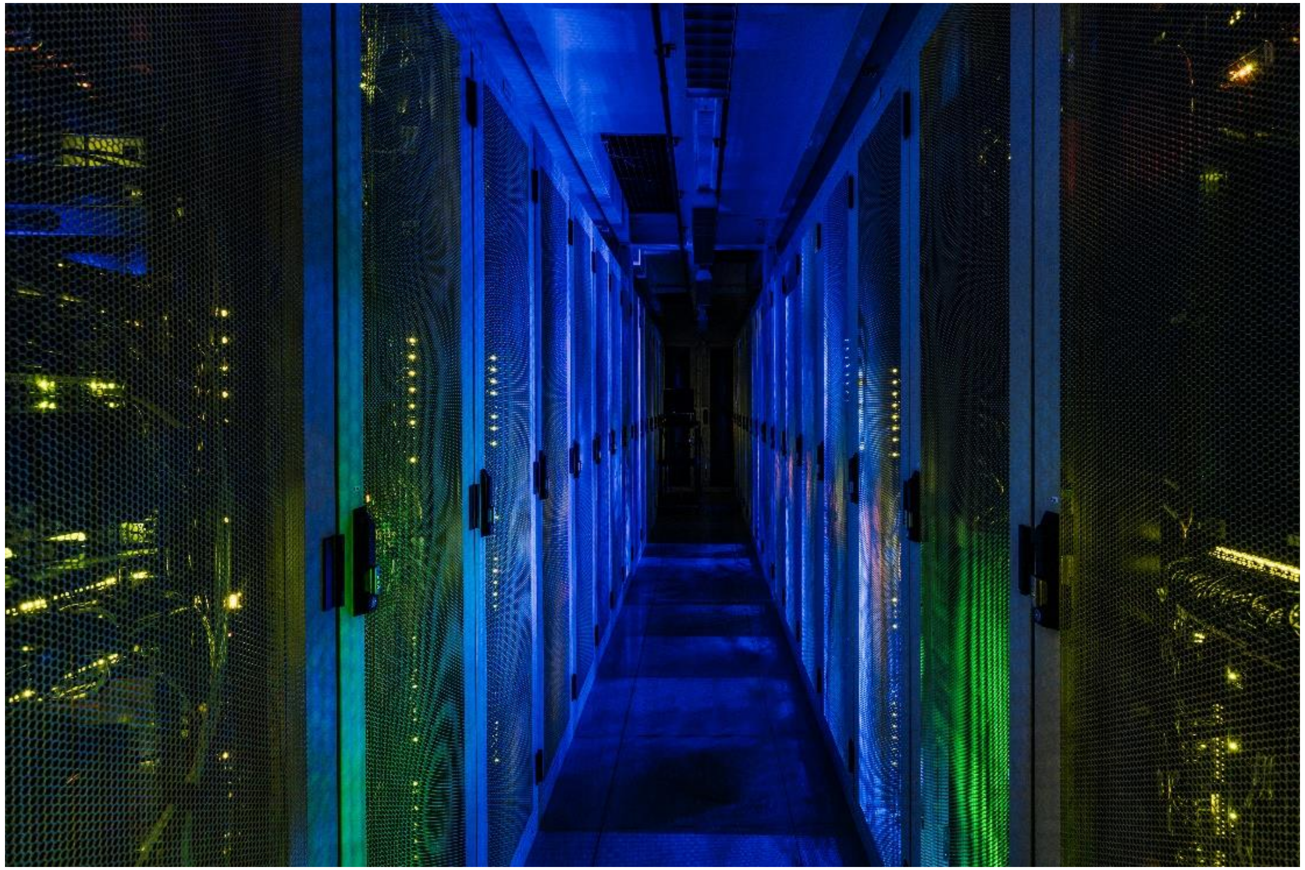
IRON MOUNTAIN

The Issue…

- Every day, our customers, and their customers are moving servers in and out of data centers *(not just Iron Mountain Data Centers!)*

- Servers, hard drives, and other IT assets need two things done in order to be effectively decommissioned – secure chain of custody/data removal, and sustainable/responsible destruction

- However, the latter is typically an afterthought for the uninformed…



IRON MOUNTAIN

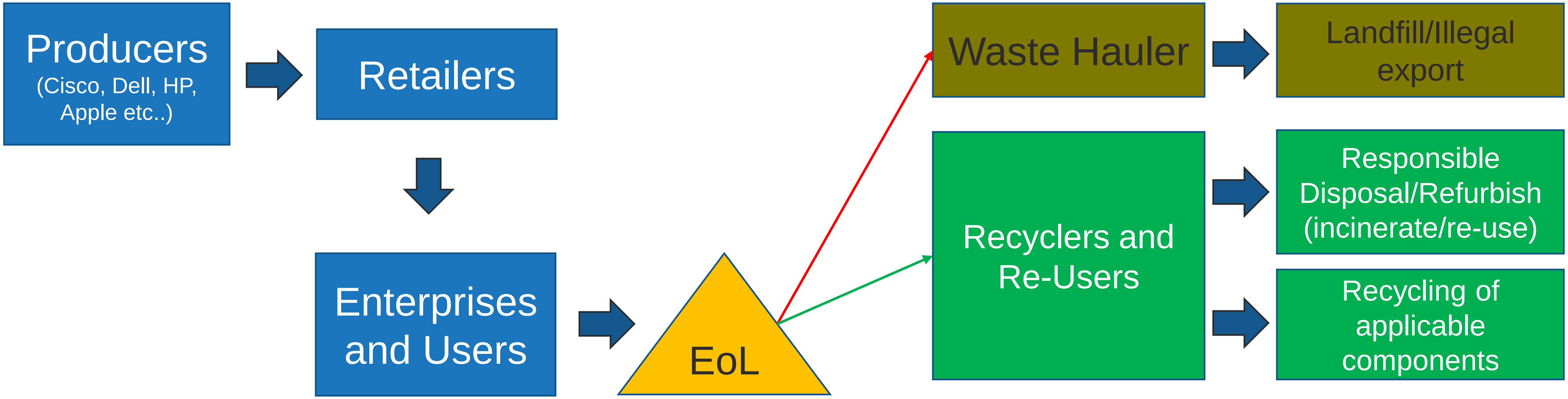
Solutions to a complex problem…

- If you rent colocation space, and own servers, you will have IT assets in your scope!

- In our process, your end-of-life products are handled in accordance with **e-Stewards** procedures — the highest compliance and regulatory standards, minimizing your carbon footprint, and boosting your green credibility

- IT equipment (desktops, laptops, servers, mainframes, printers, cable and wiring, etc.)
- office equipment (including, copiers, scanners, fax machines, phones, etc.)
- audio/visual equipment (televisions, projectors, speakers, etc.)
- data–bearing media (including tapes, hard drives, CDs/DVDs and disks)
- other assets (batteries, retail POS, medical test equipment, etc.)

Lifecycle of e-Waste



- 50 to 100 containers of e-waste arrive in Hong Kong every day, with **90** percent of it coming from the U.S
- Extraction of precious metals in 3rd world countries is typically performed by coerced, child, or extremely low wage labor

The e-Stewards Standard

- Prohibits the export of hazardous electronic waste from developed to developing countries while allowing viable technology to be reused.
- It includes the **ISO 14001** standard, so it is a "one-stop shop" for responsible used electronics management. Certified e-Stewards recyclers are independently audited to assure conformity to the e-Stewards Standard, including downstream accountability for toxic materials to final disposition

Secure Data

All stored data from all devices must be destroyed

Best Recycling Practices

Managing toxic e-waste must be done in accordance with best available practices to protect workers and the environment

Responsible Downstream Management of All Toxic Materials

e-Stewards recyclers must track all toxic materials downstream of their facilities, account for them, and ensure proper management

Ethical labor

No child, coerced, or prison labor is permitted

Legal and Responsible Exports

Exports of toxic e-waste to developing countries are not allowed in accordance with international law (Basel Convention)

Corporate-wide Conformity

e-Stewards requires that all of the facilities and operations in each country belonging to a company are covered under the certification

- The highest standard for globally responsible electronics recycling and reuse.
- Supported by the US **Environmental Protection Agency** (EPA)
- Iron Mountain Data Centers are including e-Waste in our **ISO 14001** reporting, annually, for all global locations

Wrap up/Resources

- https://www.ironmountain.com/resources/data-sheets-and-brochures/m/manage-your-end-of-life-it-assets-securely-and-responsibly

- http://e-stewards.org/

- James.Henry@ironmountain.com

IRON MOUNTAIN

Ed Daniels

Project Engineer, REMADE Institute

REMADE Institute: An Institute Overview and Summary of e-Waste Research

Presented DOE "Better Buildings and Better Plants"
November 19, 2020

Ed Daniels, Senior Program Manager, REMADE

Clean Energy, Innovation & Sustainability

ACCELERATING THE TRANSITION TO A CIRCULAR ECONOMY

Acknowledgment: "This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Advanced Manufacturing Office Award Number DE-EE0007897."

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

REMADE is a public/private partnership developing transformational technologies to accelerate the transition to a Circular Economy for plastics, metals, fibers and e-waste

- REMADE is an **industry-led membership organization**
- REMADE is forming **Strategic Partnerships** to leverage resources and maximize the opportunity for success
- REMADE is focused on developing **technology solutions** to overcome the barriers to increased remanufacturing and recycling
- REMADE plans to issue its next **Request for Proposals** in the near future
    - **Plastics Recycling** will be a key element of the RFP
    - Industry-led projects may be funded **up to $10 million per project** ($5 million federal funding and $5 million cost share)

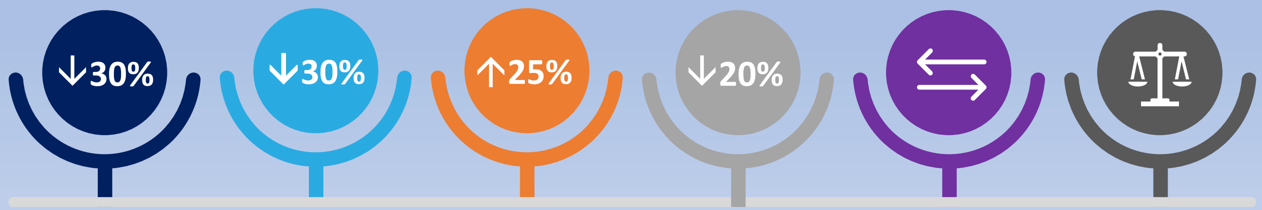
REMADE STRATEGIC GOALS

Develop **transformational technologies** that enable U.S. manufacturers to:

- Expand **recycling, recovery, remanufacturing & reuse**
- Reduce **primary materials consumption**
- Increase **utilization of secondary materials**
- Lower **energy consumption and emissions**
- Achieve **cost & energy parity** between primary and secondary materials

REMADE TECHNICAL PERFOMANCE METRICS (TPMs)

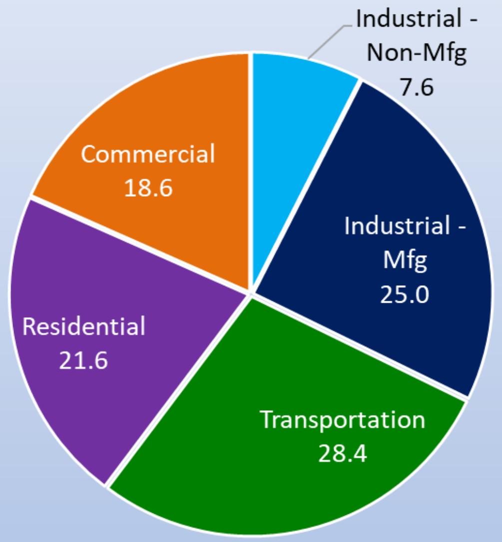
Primary Feedstock (FS) Consumed	Secondary FS Processing Energy	Embodied Energy Efficiency	GHG Emissions	Cross-Industry Reuse	Cost and Energy Parity



Reducing Embodied Energy & Decreasing Emissions, REMADE

U.S. Manufacturing

(Energy Consumption, Quads)



Responsible of ~ 25% of US Energy Consumption

REMADE Materials

Metals, Polymers, Fibers, E-waste

Current Consumption

7.0 Quads -- 228.2 Million MT of material – 600 MMT CO2 equivalent

 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.

Technology Innovation - Focus Areas (Nodes) align to Material Lifecycle

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

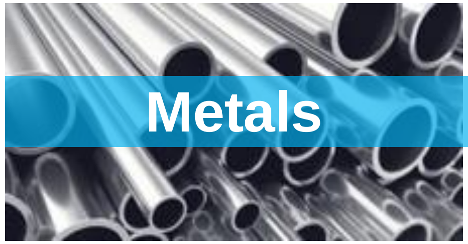
Remanufacturing/ EOL Reuse

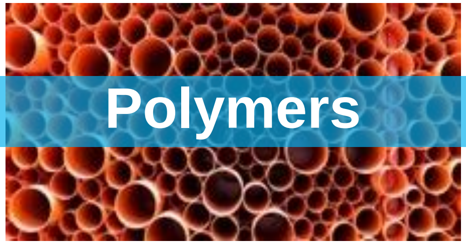
Efficient and cost effective technologies for cleaning component restoration, condition assessment, and reverse logistics

Recycling and Recovery

Rapid gathering, identificatio n, sorting, separation, contaminant removal, reprocessing and recycling

MATERIAL CLASSES



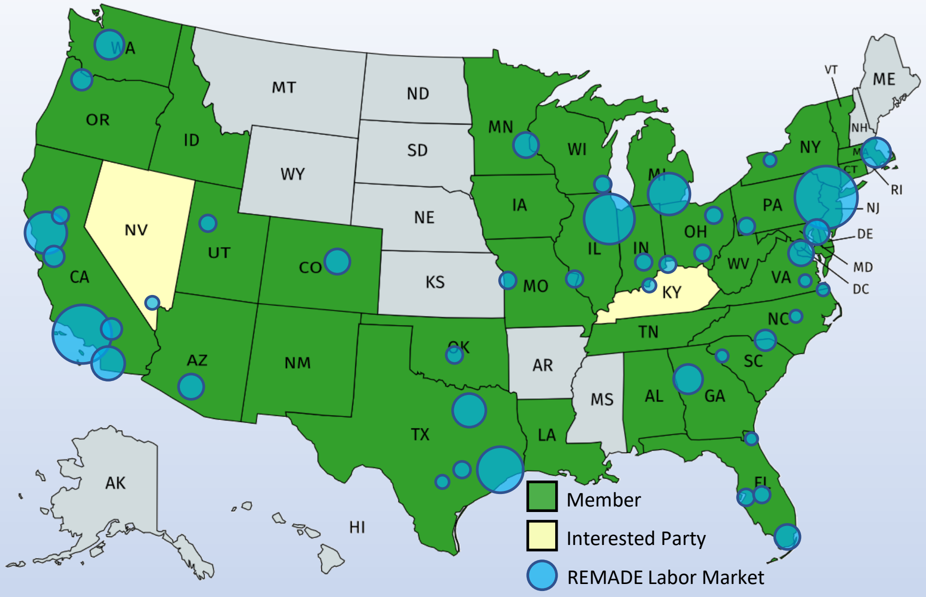


 Funding provided by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under Advanced Manufacturing Office Award Number DE-EE0007897.

REMADE Membership

- 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
- **50 member organizations are involved in 39 Institute projects selected for award**

42	27	22	5
Industry Members	Academic Partners	Affiliate Organizations	National Labs



Kent County Department of Public Works

Ohio State University

University of Michigan

Michigan State University

Institute Highlights

TECHNOLOGY

$20M invested in support of **39 projects**

3 RFPs released with 3 more planned for the next 12 months

Impact Analysis Calculator created to estimate the material efficiency and embodied energy benefits of Institute Projects

Industry-focused Technology Roadmap addresses the research priorities across the 5 nodes and 14 thrust areas

EXPECTED IMPACT

Annual savings in embodied energy **equivalent to 50 million*** **barrels of oil**

10 million* **metric tons/year GHG emissions reduced**

– the equivalent annual emissions of **5 million cars**

The Institute expects to **exceed performance goals** within the first five years of its inception

*This is the anticipated impact of the 30 Institute projects launched to date,

REMADE™ INSTITUTE

COLLABORATION

96 members with 30% growth YOY

Participated in **over 35 national events** such as Circularity 19, National Academy of Sciences Roundtable, EPA America Recycles, Ellen MacArthur Foundation Acceleration Workshop, and the World Remanufacturing Conference

Hosted 7 workshops at member sites Nike, John Deere, Michelin, University of Wisconsin Milwaukee, University of Miami, Virginia Tech, and RIT

WORKFORCE

3-Tiered Certificate strategy developed

1,500 participants in 24 training events

Over **1,200 relevant training opportunities** accessible on the REMADE website

Online Training Portal providing access to on-demand innovative training

Completed a **National labor analysis** identifying REMADE relevant occupations, skills, and competencies required of the current workforce

Estimated E-Waste Material, Energy and Emissions Impacts

- Approximately 9.5 million tons of e-Waste are generated annually
- If all e-waste were recovered and recycled:

  a) the embodied energy that would be conserved is 0.77 Quad per year
  b) the emission that would be avoided is about 48 million MT per year
- The current recycle rate for all e-Waste is estimated at 31% (weight basis)

	Total Generated	Total Currently Recovered /Conserved	Additional Recoverable
Materials Weight (1000 tons)	9496	2957	6538
Embodied Energy (Quads, 10^{15} Btu)	0.77	0.21	0.55
Emissions CO_{2e} (million MT)	48.1	13.8	34.2

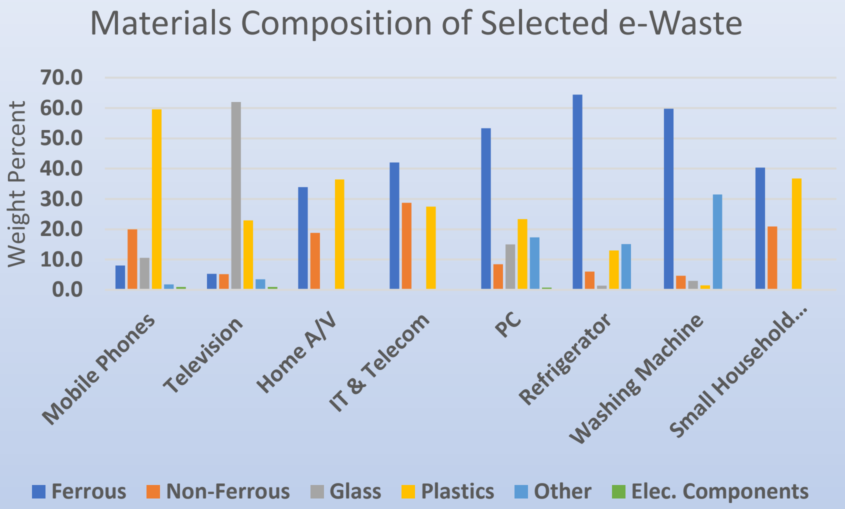
Ref. Thurston Data

Definition: "e-Waste" includes consumer electrical and electronic equipment including: 1) large appliances commonly referred to as "white goods" such as refrigerators, washing machines, microwaves, 2) IT and entertainment technologies, sometimes referred to as "brown goods" including computers, monitors, A/V systems, keyboards and mice, 3) small household appliances such as coffee makers, hair dryers, blenders, etc., and 4) mobile communications devices.

 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.

Typical Materials Composition of Components of e-Waste

- The estimated average composition of e-waste is : ferrous, 34%; non-ferrous, 17%, polymers, 33%, and others 16%.
- The materials composition of e-Waste is considerably variable depending upon a number of factors, including:
  - ✓ e-Waste product, typically large home appliances are likely to have a higher content of ferrous materials and less than 15% plastics;
  - ✓ Other products such as phones, A/V equipment, IT equipment, PC's, and small household appliances are likely to have a plastics content of more than 20-50%



Ref.

- [Data except IT and AV] R.C. Radha and P. Gurupranesh, Composition of E-Waste and Hazards Related to E-Waste. IJMER, www.ijmer.com/papers/(ICAEM)-2014/IME0141-146.pdf
- [Data for IT and AV] Mike Thurston

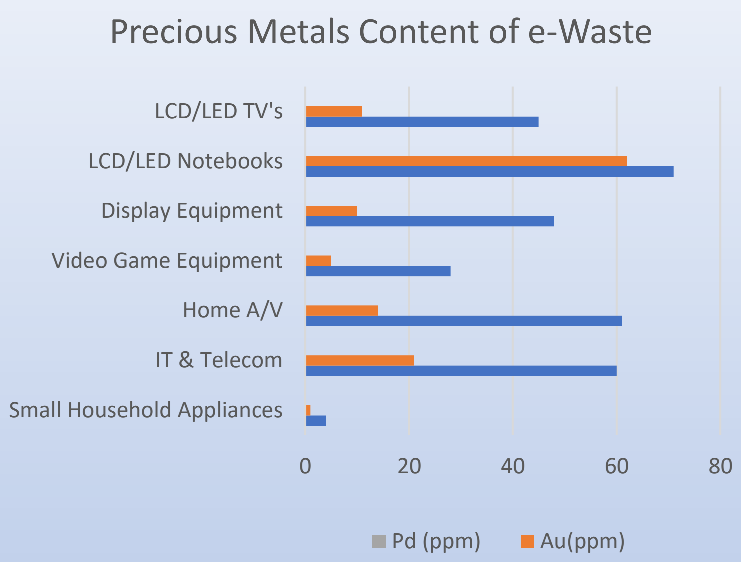
Precious Metals in e-Waste

Certain components of e-Waste contain precious metals: typically the content is less than 100 ppm.

- ✓ Sullivan of the USGS estimates that the precious metals content of mobile phones are significantly higher most e-Waste. Mobile phones are estimated to have Ag at 12,500 ppm, Au at 300 ppm, and Pt at 3 ppm. This equates to a value of $0.55 per phone. The value per MT of cell phones would be about $4600.00/MT. [5]

- ✓ Typically, precious metals that are recovered from e-waste would be recovered as components (e.g. circuit boards) in disassembly operations---the components would then be shipped to precious metals processors for recovery of the PGM.

- ✓ Anecdotal evidence suggests that the precious metals content of e-waste is decreasing and this diminishes the recycling opportunity. Any decrease in value of recycled materials from e-Waste will affect the recycle rate.



Note: Pd is less than 1 ppm

Ref.
- [**Data** for Pd] Sullivan, USGS
- [Data for Au and Ag] Mike Thurston

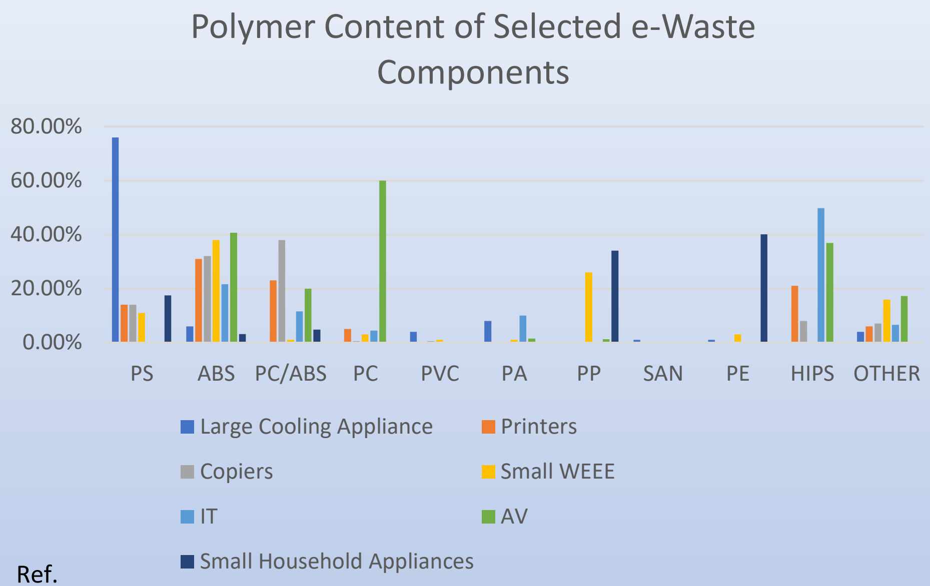
[5] D.E. Sullivan, USGS, Recycled Phones-A Treasure Trove of Valuable Metals, https://pubs.usgs.gov/fs/2006/3097/fs2006-3097.pdf

Polymer Content in e-Waste

- The polymer content of e-Waste is estimated at 3.0 million tons per year, with an embodied energy of 0.22 Quads.

- The polymer content of e-Waste is extremely variable depending on the component of e-Waste. The variation in polymer content increase the challenges of polymer recycling.

- While the composition is variable, the data indicate that certain polymer groups dominate the e-Waste polymer content: PS, ABS, PC/ABS, and HIPS.



Ref.

- [**Data** for IT and AV] Thurston reference No. 32
- [Data for Small Household Appliances] Electrical Product Material Composition, WRAP Project Code:IMT002, Oct. 2012, Banberry, England
- [All other data] Mike Thurston

Mapping the Materials Base of REMADE

Node Alignment: Systems Analysis & Integration
Materials Class(es): metals, fibers, polymers, e-waste
REMADE Project No.: 18-01-SA-05
REMADE Task No.: 10.2
Project Type: Full

Project Summary

Problem Statement:

- Existing materials' cycles that encompass the complete life-cycle of materials are out-of-date in the case of metals, incomplete in the case of fibers, or not available at the national level in the case of polymers.
- Consistent and harmonized materials cycles are required by REMADE to provide a framework to develop a common set of recycling metrics across all materials classes.

Project Goals/Objectives:

- To develop a harmonized set of material cycles for metals (steel and aluminum), fibers, polymers and e-waste, illustrating how materials are processed, used, reused, remanufactured, recycled, and disposed of (U.S., world).
- To develop a common set of recycling metrics across REMADE materials.
- To develop a set of scenarios on the supply and demand of REMADE materials in Institute years 5 and 10.
- To develop detailed life cycle information for metals, fibers, polymers, and electronics for Institute years 0, 5, and 10.

Project Impact

Impact versus the Technical Performance Metrics (TPMs):

- By providing a baseline this project targets TPMs 1, 2, 7 (for anticipated reductions in primary and secondary feedstock use in manufacturing), TPM 3 (for increases in recycling efficiencies of energy-intensive materials), and TPM 4 (for embodied energy efficiency improvements in years 5 and 10).

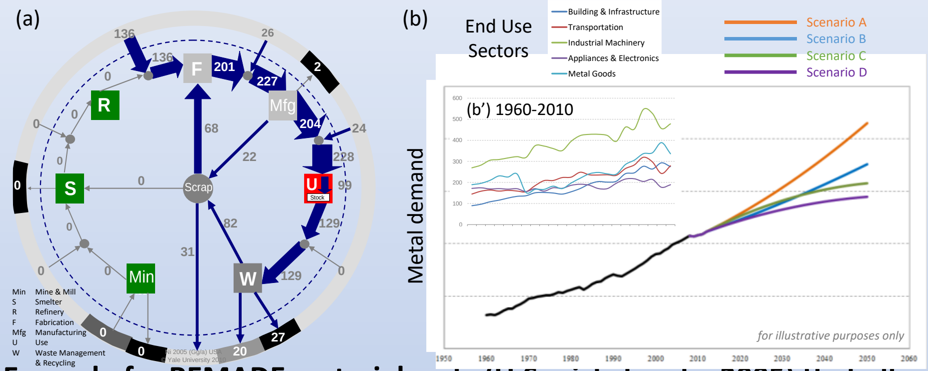
Target Industries and Materials/Material Classes:

- Impacted material classes are metals, fibers, polymers, and e-waste.

Technology Transition Plan:

- All REMADE members will be informed by the project.

Project Schematic



(a) Example for REMADE material cycle (U.S. nickel cycle, 2005) that allows calculation of recycling metrics. (b) Example for metal demand scenarios, informed by (b') historic U.S. end use sector information.

Project Team, Funding, Schedule

Project Team:

- Yale University / Barbara Reck
- Massachusetts Institute of Technology / Elsa Olivetti
- Unilever / James Turbett
- Institute of Scrap Recycling Industries / David Wagger
- Sunnking / Adam Shine

Project Funding:

- REMADE Funding ($K): $285
- Total Project Funding ($K): $570

Cost-share ($K): $285
Industry Cost Share ($K): $19

Project Schedule:

- Project Duration (months): 18
- Project Start Date: Oct. 2019

This slide does not contain any proprietary information.

 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.

Evaluation of Logistics Systems for Collection, Preprocessing and Production of Secondary Feedstocks from E-waste

Node Alignment: Systems Analysis & Integration
Materials Class(es): electronic waste
REMADE Project No.:18-01-RR-18
REMADE Task No.:6.8
Project Type: Full

Project Summary

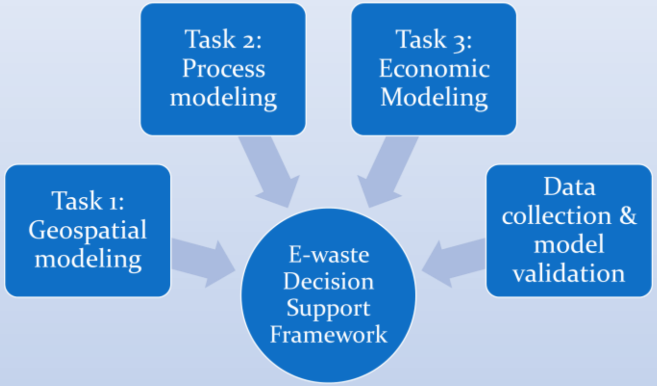
Problem Statement:

- Electronic waste recycling is a growing industry. However, currently the industry is failing to capture a large segment of the resources, while having cost and energy consumption that does not compare favorably to primary feedstocks.
- These issues point to inefficiency in the supply chain. Inefficiency is endemic of not having a system-wide understanding of the supply chain and making decisions.

Project Goals/Objectives:

- We propose to develop a decision support framework (DSF) for e-waste recycling and refurbishment that is spatially explicit and accounts for dynamic market conditions for recycling recycled and refurbished commodities.
- This DSF will identify optimal supply chain configurations that reduce recycling/refurbishing costs and energy consumption based on available technology, market conditions, and the spatiotemporal relationships of supply chain actors.

Project Schematic



Flow of information for the development of an e-waste Decision Support Framework

Project Impact

Impact vs the Technical Performance Metrics (TPMs):

- This project does not directly impact the REMADE Technical Performance Metrics, rather the outcome of this project will be a tool that can be utilized by e-waste recycling companies to evaluate their operations based on several factors including energy usage, energy efficiency, etc.

Target Industries and Materials/Material Classes:

- Target Industry: Recycling
- Materials/Material Classes: E-Waste

Technology Transition Plan:

- The open-source DSF will provide the modeling framework; generic models will be provided to industry will all proprietary data removed.
- The training materials, user documentation, and open-source software will be made available on a Github site.

Project Team, Funding, Schedule

Project Team:

- Idaho National Laboratory/ Damon S. Hartley, PhD - PI
- Idaho National Laboratory/ Ruby Nguyen, PhD
- Idaho National Laboratory/ Mike Griffel, MSc.
- Sunnking, Inc/ Matthew Plummer
- Sunnking, Inc/ Adam Shine

Project Funding:

- REMADE Funding ($K): $500 — Cost-share ($K): $500
- Total Project Funding ($K): $1000 — Industry Cost Share ($K): $500

Project Schedule:

- Project Duration (months): 24
- Project Start Date: January 2020

This slide does not contain any proprietary information.

Condition of Assessment of Used Electronics

Node Alignment: Remanufacturing and EOL Reuse
Materials Class(es): Electronics
REMADE Project No.: 18-01-RM-14
REMADE Task No.: 7.5
Project Type: Exploratory

Project Summary

Problem Statement:

- Solder joints and interconnects amount to about 13% of all electronics failures, most of which, when detected, can be effectively repaired during remanufacturing.
- There are no *reliable non-destructive examination* (NDE) methods for testing common failures in *printed circuit boards* (PCBs), interconnections, and solder joints.

Project Goals/Objectives:

- Develop a decision support tool for identifying critical solder joint and interconnect latent failure modes in printed circuit boards (PCBs) based upon non-destructive evaluation (NDE) inspection methods.
- Test the effectiveness and performance of existing methods in a laboratory and investigate the ability to streamline and automate the associated process to make them technically and economically feasible for use in PCB remanufacturing.

Project Impact

Impact vs the Technical Performance Metrics (TPMs):

- Increase in reuse rate and reduction in embodied energy.
- Embodied energy savings: 4.5 PJ
- Decrease in primary materials use: 224,000 MT

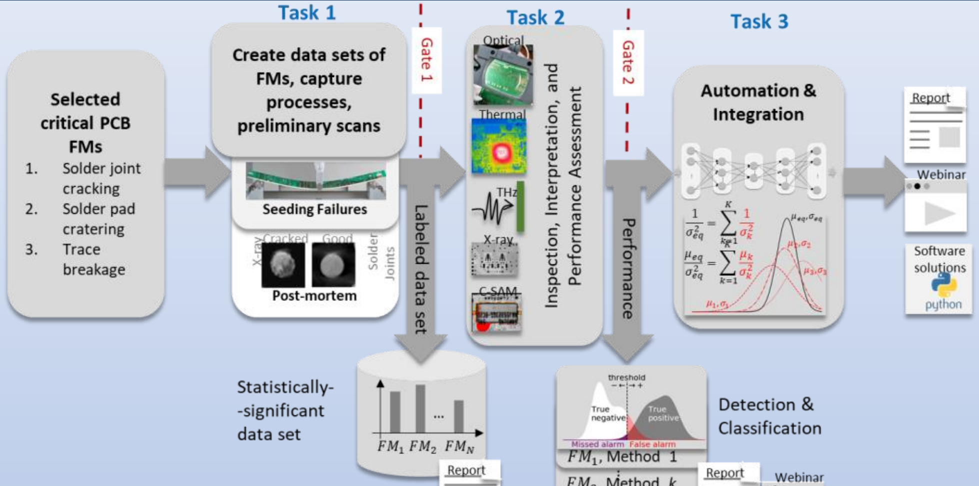
Target Industries and Materials/Material Classes:

- Heavy duty industry, automotive, and consumer electronics.
- The affected materials were identified based upon the mass composition of PCBs: 28% metals, 23% plastics, and reminder ceramics and glass.

Technology Transition Plan:

- The integrated system and its components will be demonstrated at one or both industrial partners.
- Industrial partners will adopt the developed technology and integrate them into their operations.

Project Schematic



PCB = Printed Circuit Board
FM = Failure Mode

Project Team, Funding, Schedule

Project Team:

- Rochester Institute of Technology/Nenad Nenadic
- CoreCentric Solutions/ Mark Schau
- Caterpillar/ Christopher Stickling

Project Funding:

- REMADE Funding ($K): $500 — Cost-share ($K): $574
- Total Project Funding ($K): $1074 — Industry Cost Share ($K): $60

Project Schedule:

- Project Duration (months): 18
- Project Start Date: March 2020

This slide does not contain any proprietary information.

 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.

Epoxy/Silicone Potting Material Removal for Greater Recovery of Circuit Boards

Node Alignment: Remanufacturing & EoL Reuse
Materials Class(es): Electronics
REMADE Project No.: 18-01-RM-13
REMADE Task No.: 6.0
Project Type: Exploratory

Project Summary

Problem Statement:

- Potting material is intended to protect electronics, but also prevents repair and reuse, resulting in electronic components being scrapped.
- Remanufacturing of PCBs is currently limited by the ability to effectively remove potting material from the surface of electronic circuit boards without damaging the exposed components or other section of the PCB.
- The baseline process used by industry today operates on very small local areas manually, with removal on the order of 10-30 minutes; because of cost, this is only used on very low volume repairs of high value components.

Project Goals/Objectives:

- The project will investigate the feasibility of laser ablation and microblasting for removal of potting materials to enable remanufacturing of electronic components that are otherwise scrapped.
- Both technologies have been used for removal of conformal coatings.

Project Impact

Impact vs the Technical Performance Metrics (TPMs):

- 2.1 MMT material savings
- 42 PJ Embodied energy savings.

Target Industries and Materials/Material Classes:

- Heavy Duty, Automotive, Durable consumer goods
- Electronics

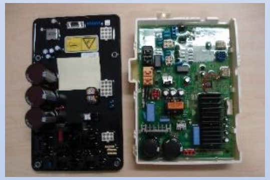
Technology Transition Plan:

- Process will be demonstrated at partner facilities as a first step in transition.

Project Schematic

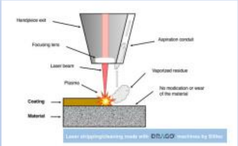
Task 1: M1-M3	Task 2: M4-M6	Task 3: M7-M9	Task 4: M10-M12
• Establish success criteria • Prepare test samples • Finalize test plan	• Feasibility testing of both technologies	• Process Refinement and Optimization of both technologies	• Process conformation and demonstration

Example Parts

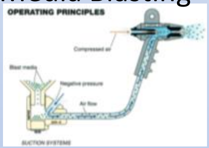


Research Technologies

Laser Ablation



Media Blasting



Result: cost effective potting removal process

Project Team, Funding, Schedule

Project Team:

- Rochester Institute of Technology / Kristi Schipull
- Caterpillar Inc. / Cesar Carbajal
- CoreCentric Solutions/ Mark Schau

Project Funding:

- REMADE Funding ($K): $100 — Cost-share ($K): $100
- Total Project Funding ($K): $200 — Industry Cost Share ($K): $24

Project Schedule:

- Project Duration (months): 12
- Project Start Date: March 2020

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Low-Cost, High-Value Metal Recovery from Electronic Waste to Increase Recycling and Reduce Environmental Impact

Node Alignment: Recovery and Recycling
Materials Class(es): E-waste
REMADE Project No. 18-02-RR-06
REMADE Task No. 6.11
Project Type: Exploratory

Project Summary

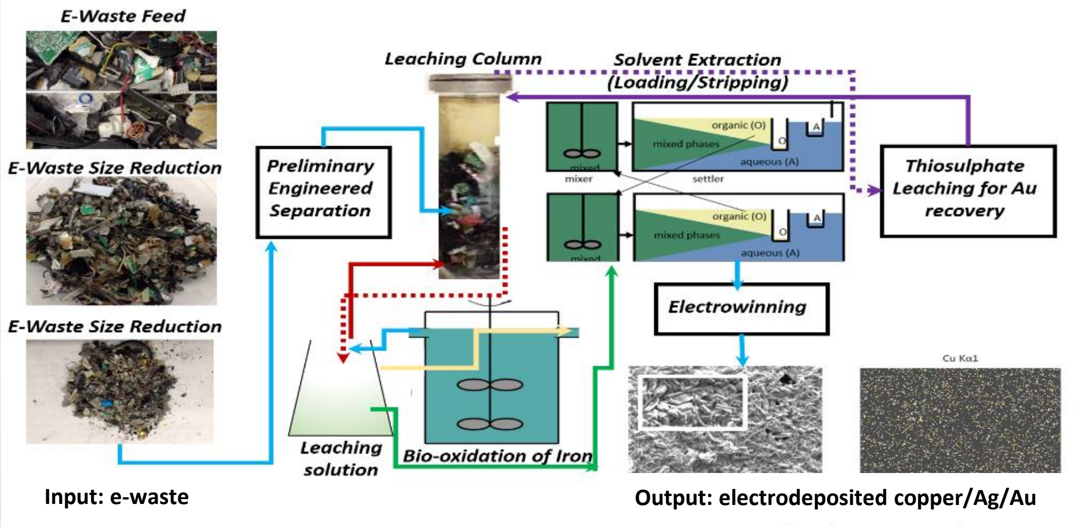
Problem Statement:

- The global amount of e-waste reached 44.4 million tons in 2016.
- The production of electronic waste (or electronic scrap) materials is growing, but the value recyclers receive for e-waste is limited by the yield, quality and hence value of materials recovered from e-waste via conventional technology.

Project Goals/Objectives:

- The main objective of this project is to utilize commercial low-cost, bio-oxidation or chemical oxidation driven heap leaching, solvent extraction (or ion-exchange resin for precious metals), and electrowinning technologies to directly recover high-purity copper and precious metals from e-waste and to chemically separate metals from plastic. This will increase the cost-effectiveness of e-waste recycling and contribute to increasing the quantity of e-waste recycled.

Project Schematic



Input: e-waste

Output: electrodeposited copper/Ag/Au

Project Impact

Impact versus the Technical Performance Metrics (TPMs):

- 0.55 million MT decrease in primary material use
- 20.7 PJ embodied energy savings
- 1.2 million MT reduction in CO_2eq

Target Industries and Materials/Material Classes:

- Electronic waste recyclers
- E-waste
- Copper and precious metals

Technology Transition Plan:

- A cost analysis of the proposed process relative to alternatives will be prepared by the PI's to build the case for a pilot-demonstration

Project Team, Funding, Schedule

Project Team:

- Lead Organization/Principal Investigator : University of Utah / Prashant K Sarswat Team Member Organization/ Contact : University of Utah / Michael L. Free
- Team Member Organization/ Contact: University of Utah / Arun Murali

Project Funding:

- REMADE Funding ($K): $100 Cost-share ($K): $100
- Total Project Funding ($K): $200 Industry Cost Share ($K): $50

Project Schedule:

- Project Duration (months): 12
- Anticipated Project Start Date: Oct. 2019

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 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 INSTITUTE

Chemical Recycling of Mixed Plastics and Valuable Metals in the Electronic Waste Using Solvent-Based Processing

Node Alignment: Recovery and Recycling
Materials Class(es): Polymers, E-waste
REMADE Project No.: 18-02-RR-17
REMADE Task No.: 6.12
Project Type: Exploratory

Project Summary

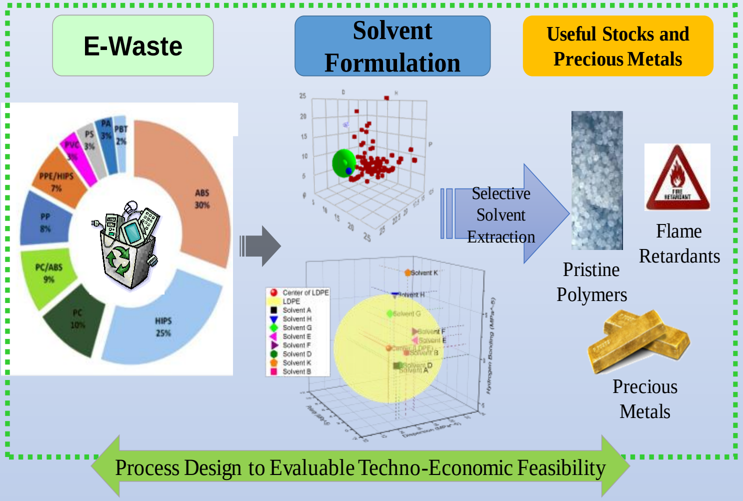
Problem Statement:

- Annually, 20-55 million tons of electronic waste (e-waste) are produced worldwide (equaling 5% of municipal solid waste). Although e-waste embodies only 2% of America's municipal waste, it accounts for significant amounts of heavy metals and flame retardants.
- Currently, less than 20% of e-waste is recycled.
- E-waste typically contains around 25% iron/steel, 5% non-ferrous metals (mostly aluminum and copper), 10% printed circuit boards (PCBs), 25-30% plastics, 30% glass (CRT and flat panel) and 2-3% batteries.

Project Goals/Objectives:

- The objective of this project is to demonstrate the potential of a solvent-based processing to produce secondary materials (plastics and metals) from e-waste for cross-industry reuse.

Project Schematic



Tasks for this project: 1) identify the major metal and plastic compositions in ESR, 2) formulate solvent and anti-solvents to recover targeted plastics and separate BFRs, respectively, and 3) develop a process deign model to evaluate the techno-economic feasibility of the proposed solvent-based processing.

Project Impact

Impact versus the Technical Performance Metrics (TPMs)

- Achieve 25% improvement in embodied energy efficiency in 5 years.
- Achieve 10x reduction in primary material feedstock and 20% reduction in associated GHG.
- Save 16.5 PJ of energy per year
- Reduce GHG emissions by 334,000 metric tons annually

Target Industries and Materials/Material Classes

- Electronics, appliance, and automobile recycling industries
- Electronic materials and plastics
- Plastics and metals purified from this project can be potential cross-industry feedstocks this project might generate.

Technology Transition Plan

- Discuss licensing opportunities with e-waste recyclers and plastic recyclers via ISRI's membership and UML's network.

Project Team, Funding, Schedule

Project Team:

- Lead Organization/Principal Investigator: U Mass Lowell, Wan-Ting (Grace) Chen
- Graduate Student: U Mass Lowell, Lester Anderson
- Team Member Organization/ Contact: Sunnking, Inc, Matthew Plummer
- Team Member Organization/ Contact: Sunnking, Inc., Adam Shine
- Team Member Organization/ Contact: ISRI, David Wagger

Project Funding:

- REMADE Funding ($K): $89 Cost-share ($K): $91
- Total Project Funding ($K): $180 Industry Cost Share ($K): $40

Project Schedule:

- Project Duration (months): 12
- Project Start Date: Jan. 2020.

This slide does not contain any proprietary information.

 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.

Questions

https://remadeinstitute.org

Questions?

~Please utilize the chat box for questions~

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