Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 200-EH**

Resource Recovery from E-waste to Conserve Natural Resources

Category: H. Proposals seeking $200,000 or less in funding

Sub-Category: E. Air Quality, Climate Change, and Renewable Energy

Total Project Budget: $ 199,010

Proposed Project Time Period for the Funding Requested: June 30, 2022 (2 yrs)

Summary:

The project will analyze the challenges and opportunities to recover hazardous and valuable materials from electronic waste to conserve natural resources, reduce greenhouse gases, and to create local jobs.

Name: Shashi Rao

Sponsoring Organization: U of MN - Duluth NRRI

Job Title: Mr.

Department: Natural Resources Research Institute

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Duluth MN 55811

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Web Address: https://www.nrri.umn.edu/

Location:

Region: Statewide

County Name: Anoka, Carver, Chisago, Dakota, Hennepin, Isanti, Ramsey, Scott, Sherburne, Stearns, Washington, Wright

City / Township: Minneapolis-Saint Paul

Alternate Text for Visual:

Evaluating Challenges and Opportunities for Material Recovery from E-waste in Minnesota:Conservation of Scarce Resources and Protection of Environment

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base	
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency	
_____ Capacity Readiness	_____ Leverage		_____ TOTAL	_____%

PROJECT TITLE: RESOURCE RECOVERY FROM E-WASTE TO CONSERVE NATURAL RESOURCES

I. PROJECT STATEMENT

The goals of this study are to:

1. Identify specific success factors and barriers for material recovery from e-waste in Minnesota;
2. Identify opportunities to **modernize** equipment, technologies, and processes to ensure safe recovery of valuable and hazardous components of electronic waste (e-waste) in Minnesota;
3. Compare the e-waste management systems in Minnesota with e-waste recovery in regions where material recovery is operating successfully (these countries/states include Finland, Sweden, Belgium, Germany, South Korea, Japan, New York, California, and others) via literature search;
4. Establish analytical methods to characterize materials present in the e-waste.
5. Characterize the chemical composition of e-waste from certified recyclers in the Minnesota Metro area
6. Provide the State of Minnesota with a report that includes: 1) state-of-the-art information about e-waste material recovery technologies, equipment, and processes; and 2) data on the material and chemical composition of electronic waste; and 3) a technology roadmap for establishing state-of-the-art processing of e-waste in the State.

Electronic waste is the fastest growing domestic waste stream. According to the Minnesota Pollution Control Agency's (MPCA) 2013 Waste Characterization Study, electronic products made up about 1.2 percent (70 million pounds) of all material disposed of as mixed municipal solid waste in 2012. Moreover, the U.S. Environmental Protection Agency (EPA) estimates that over 720 million new electronic products were sold, and **6.7 billion pounds** of used electronics were ready for end-of-life management in 2014 alone. With aggressive goals (75% by 2030), for recycling in Minnesota statute (MN 115A.551 Subd. 2a) for the seven-county Metro Area, there is a growing need for material recovery and recycling infrastructures and their capacity for handling the increasing number of obsolete electronic devices. Additionally, given the need to curb **natural resource depletion** and **climate change**, there is a growing need for recovery of resources domestically in a way that decreases the **environmental burdens** associated with extraction of primary raw materials. In Minnesota, approximately 199.4 million pounds of household electronic waste was collected for recycling between 2013 and 2018. Minnesota **does not** have certified resource recovery facilities to convert the e-waste materials into **useable** products. As a result, it is a common practice for registered recyclers, retailers, and equipment manufacturers in Minnesota to **export** the electronic waste materials to downstream vendors in other states or **international markets** for material and value recovery. At present, registered recyclers in Minnesota have **minimal capabilities** to convert e-waste into valuable raw materials. By accomplishing the aforementioned objectives, a technology roadmap will be created to guide the State of Minnesota in establishing **state-of-the-art** processing infrastructure to provide the value-added processing services.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1 Title: Assess Current Practices at Existing E-Recycling Facilities **ENRTF BUDGET: $60,126**

Description: The project team will visit certified recycling facilities in the Metro area and review their existing material recovery practices. The team will also identify opportunities for and barriers to increasing the recyclability of electronic devices, specifically addressing recycling or safe disposal of electronic devices and low-value materials recovered from those devices.

Activity 2 Title: Review Existing Best Practices in Material Recovery from E-waste **ENRTF BUDGET: $25,789**

Description: The project team will perform a combination of literature research and stakeholder surveys to review best practices for material recovery from electronic wastes. The project team will review the literature to gather information related to equipment, technology, and processes that are currently used to recover plastics, glasses, metals, and hazardous materials from electronic wastes. The team will also interview experts from industry, original equipment manufacturers, recyclers, and academia to obtain their views on challenges and opportunities for material recovery from e-waste.

Activity 3 Title: E-waste Composition Analysis

Description: A compositional analysis of metallic and non-metallic streams of e-waste collected from certified recyclers will be performed using scientifically established methods. The waste characterization will include toxicity characteristic leaching procedure (TCLP), heavy metals, rare earth metals, precious metals, base metals, and high technology metal elemental analysis. Additionally, the plastic fractions from e-waste will be characterized for furans, dioxins, poly brominated diphenyl ethers (PBDE), poly brominated biphenyls (PBBs), and polychlorinated biphenyls (PCB's). **ENRTF BUDGET: $113,095**

Outcome	Completion Date
1. A database of existing best practices to recover valuable metals, plastics, and glass from end-of-life electronic devices.	*06/30/2021*
2. Identify bottlenecks for material recovery at a certified recycling facility in Minnesota	*06/30/2021*
3. Categorize material characteristics of e-waste and e-scrap at certified recycling facilities	*06/30/2021*

III. PROJECT PARTNERS AND COLLABORATORS: Shashi Rao. M. S. (Principal Investigator), George Hudak Ph. D. (Geology), Kevin Kangas M. S., MBA (Chemical Engineer), Eric Singsaas Ph. D (Wood Products and Bio-economy), Brett Spigarelli Ph. D. (Chemical Engineer), Meijun Cai Ph. D.(Environmental Engineer), Will Bartsch M. S., (Water Resources Scientist), Victor Krause B. S. (Chemistry) and Matthew Mlinar MBA. (Electrical Engineer).

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

This project will provide data for initial execution of the transition to near zero waste and circular economy for electronic waste in Minnesota. This will be done by identifying the current state of the art technologies, processes, and equipment used to **increase recovery/recyclability** of materials from e-waste, and identifying additional**, specialized capacity** that would be needed at existing recycling facilities to convert waste materials into **usable products**.

In the long term, recovering materials from e-waste has three significant benefits.

- One: E-waste represents a significant opportunity to recover scarce raw materials and thereby helps in **conserving natural resources**.
- Two: E-waste contains toxic materials such as mercury, cadmium, lead, hexavalent chromium, and brominated flame-retardants that **pose hazards to public health** and the **environment** if not properly disposed or recycled. Emissions resulting from the end of life treatment may **release hazardous compounds** into the environment, such as dioxins and furans.
- Three: Recovering materials implies **reduction** in the need for new raw materials, thus minimizing **greenhouse gases**, waste, and energy while creating **new jobs** and **business opportunities**.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Shashi Rao
Project Title: Resource Recovery from E-waste to Conserve Natural Resources
Organization: University of Minnesota Duluth, Natural Resources Research Institute
Project Budget: 199,010
Project Length and Completion Date: 1 Year 07/01/2020 - 06/30/2021
Today's Date: 04/10/2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ -	$ -	$ -
Shashi Rao, Project Manager, $30,298 (sal. 74%; fringe 26%) 25% FTE; Brett Spigarelli, Collaborator, $13,364 (sal. 74%; fringe 26%) 10% FTE; Matthew Mlinar, Collaborator, $13,389 (sal. 74%; fringe 26%) 10% FTE; Kevin Kangas, Collaborator, $3,608 (sal. 74%; fringe 26%) 2% FTE; George Hudak III, Collaborator, $3,703 (sal. 74%; fringe 26%) 2% FTE; Eric Singsaas, Collaborator, $3,634 (sal. 74%; fringe 26%) 2% FTE; Will Bartsch, Collaborator, $3,361 (sal. 74%; fringe 26%) 4% FTE; Meijun Cai, Collaborator, $3,865 (sal. 74%; fringe 26%) 4% FTE; Victor Krause, Collaborator, $1,719 (sal. 74%; fringe 26%) 4% FTE; Total Costs=$76,941	$ 76,941	$ -	$ 76,941
*** NOTE: NRRI research staff salaries are largely sponsored by external funds**			
Professional/Technical/Service Contracts			
Characterization of electronic wastes from Minneapolis-Saint Paul Metro area Registered Recycling Facilities: Toxicity characteristic leaching procedure (TCLP) @ $265/sample X 30 samples=$7950; Rare earth elements, heavy metals, precious metals, high technology metal elemental analysis: $900/sample. X 30 samples=$27,000 Chlorine, Bromine, Heavy metal analysis of plastics and glass- $300/sample X 30 samples=$9,000; furans and dioxins-$350/sample X 30 samples=$10,500; PBDE, PBBs PCB's analyses:$1200/sample X 30 samples=$36,000. Image analysis using x-ray spectra- $910/sample X 5 samples=%4,550.Total Costs $95,000	$ 95,000	$ -	$ 95,000
Equipment/Tools/Supplies			
	$ -	$ -	$ -
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
		$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
Up to 40 days of actual costs for food and lodging for project manager and one collaborator (UMN guidelines regarding reimbursement for these costs will be followed) = $18,160. Reimbursement for mileage related to Minneapolis-Saint Paul Metro Area: Project Manager and one collaborator travel back and forth to NRRI, 1 crew x 40 trips x 384 miles roundtrip = $8,909 Total costs $27,069	$ 27,069	$ -	$ 27,069
Other			
	$ -	$ -	$ -
COLUMN TOTAL	$ 199,010	$ -	$ 199,010

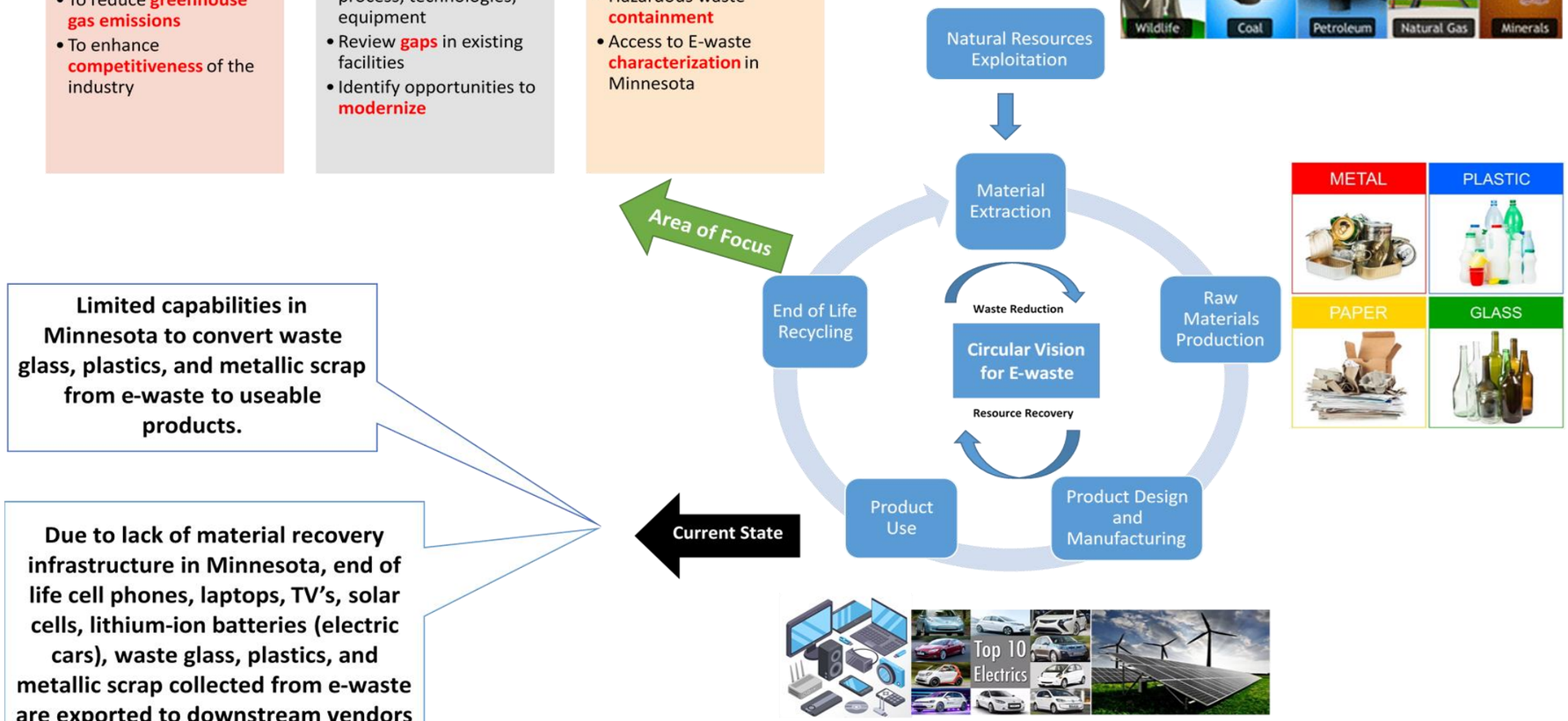
SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: University of Minnesota unrecovered indirect at 54% of MTDC. Base= $199,010	secured	$ 107,465	$ -	$ 107,465

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

Evaluating Challenges and Opportunities for Material Recovery from E-Waste in Minnesota: Conservation of Scarce Resources and Protection of Environment

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Goals	Approach	Impact
• To **conserve** natural resources • To **protect** public health and the environment. • To create **local jobs** • To reduce **greenhouse gas emissions** • To enhance **competitiveness** of the industry	• Identify missing **technologies**. • Reduce **knowledge deficit** on e-recycling • Identify **state of the art** process, technologies, equipment • Review **gaps** in existing facilities • Identify opportunities to **modernize**	• **Research** infrastructure development • Material recovery **infrastructure** development • Hazardous waste **containment** • Access to E-waste **characterization** in Minnesota



Environment and Natural Resources Trust Fund (ENRTF)
2020 Main Proposal Visual
Project Title: Resource Recovery from E-waste to Conserve Natural Resources

Closing the Material Loop in the Electronics Industry to Deliver the United Nations Sustainable Development Goals

PROJECT TITLE: Resource Recovery from E-waste to Conserve Natural Resources

2020 LCCMR Project Manager Qualifications and Organization Description

Mr. Shashi Rao, Natural Resources Research Institute, University of Minnesota Duluth

EDUCATION

- Master of Engineering Science in Metallurgical Engineering 2012-2013
  Curtin University, Australia

- Bachelor of Technology in Metallurgical and Materials Engineering 2006-2010
  National Institute of Technology Karnataka, India

RELEVANT RESEARCH EXPERIENCE

- Researcher 5, University of Minnesota Duluth Natural Resources Research Institute, 2014-Present
- Metallurgical Engineering Intern, Cobar Consolidated Resources Limited, Australia, 2012-2013
- Graduate Metallurgical Engineer, JSW Steel Ltd, India, 2010-2011
- Metallurgical Engineering Intern, Hindustan Aeronautics Limited, India, 2008

KEY QUALIFICATIONS

Mr. Shashi Rao is a researcher, and a metallurgical engineer at the Natural Resources Research Institute (NRRI), a Minnesota-based research institute focused on delivering research solutions to balance Minnesota's economy, resources and environment for resilient communities. Mr. Rao's research focuses on waste minimization and materials recycling, wastewater treatment, materials production for clean energy, circular economy, extraction of critical metals, social innovations, among other topics. Mr. Rao will be responsible for overseeing the proposed project. Mr. Rao will be responsible for working with George Hudak Ph. D. (Geology), Kevin Kangas M. S., MBA (Chemical Engineer), Eric Singsaas Ph. D (Wood Products and Bio-economy), Brett Spigarelli Ph. D. (Chemical Engineer), Meijun Cai Ph. D.(Environmental Engineer), Will Bartsch M. S., (Water Resources Scientist), Victor Krause B. S. (Chemistry) and Matthew Mlinar MBA. (Electrical Engineer) to ensure that project goals, results, and timelines are met.

The Natural Resources Research Institute is a University of Minnesota Duluth applied research organization. NRRI's mission is to deliver research solutions to balance Minnesota's economy, resources and environment for resilient communities. The collective research and organizational experiences of the project team members and the resources available to this project from the University of Minnesota Duluth should ensure the successful completion of the proposed project goals.