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

Project Title: **ENRTF ID: 177-E**

Converting Forest Products Industry Waste to Value-Added Bioproducts

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

Sub-Category:

Total Project Budget: $ 309,000

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

Summary:

We propose to reduce solid waste and greenhouse gas emissions from landfills by converting biomass in solid waste from forest products industry to value-added products and improve Minnesota's forest bioeconomy.

Name: Shri Ramaswamy

Sponsoring Organization: U of MN

Job Title: Prof.

Department: Department of Bioproducts and Biosystems Engineering

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Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Innovative approaches to reducing solid waste and GHG emissions and efficiency improvement in MN's forest products industry thus contributing to a strong forest bioeconomy in greater Minnesota

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

Converting Forest Products Industry Waste to Value-Added Bioproducts: Innovative approaches to reduce solid waste and GHG emissions and efficiency improvement in MN's forest products industry thus contributing to a viable forest bioeconomy in greater Minnesota

I. Project Statement We propose to reduce solid waste and associated greenhouse emissions (*research funding priority E*) from landfills by converting biomass in solid waste from forest products industry to value-added products and improve Minnesota's forest economy. Key outcomes from this work are: i) reducing waste and GHG emissions delivering multiple benefits to environment and natural resources, ii) creating new value-added products and additional revenue, iii) improve operational efficiency, iv) strengthening Minnesota's forest industry and rural bio-economy. The forest products industry partners and collaborators are very supportive of this work and interested in implementing potential solutions.

Minnesota's forest products industry has been under immense global pressure for several years just to survive. Saw mills, lumber and building materials manufacturers and pulp and paper mills in MN produce a significant amount of highly valuable residue (solid waste) that contains recoverable, renewable biomass in the form of saw dust, shavings, chips and short cellulosic fibers. This is a potential source of renewable carbon that has been thus far overlooked. In addition to primary biomass resources such as forest residues, the biomass in solid waste residue has the multiple benefits of providing the renewable carbon feedstock as well as reducing solid waste and GHG emissions, improve operational efficiency, benefit the forest products industry and the forest based bio-economy in greater Minnesota.

We propose to separate the lignocellulosic biomass from solid waste and convert them into value added products including biofuels, bio-chemicals and biodegradable bioplastics. The remaining inorganic residue from the solid waste can then be used as soil amendment or for land use applications. For example, Minnesota's mills a produce the above solid waste and liquid effluent and rely either on their own waste treatment plant or use local city waste treatment facilities to handle the effluent and landfill their solid waste. Forest products industry in MN is currently seeking options for economic use of these residues. We propose to take the above solid waste residues, separate the organic, renewable carbon and using thermochemical and biochemical means convert them to useful bioproducts. In addition to reducing solid waste currently being disposed in landfill and associated greenhouse gas generation and improving operational efficiency, the proposed project will also add economic value to MN's forest products industry making them more viable in the future and contribute to a strong rural bio-economy in greater Minnesota for years to come.

II. Project Activities and Outcomes

Activity 1: Waste Characterization and Organic Separation

Description: Working with our industrial partners and collaborators, we will collect and analyze the composition of the solid waste streams for their organic content, physical and chemical characterization and short fiber content. (**Budgeted amount: $80,110) (Project Start Date July 1, 2020)**

Outcomes	Completion Date
1. Collect and analyze the solid waste stream from Minnesota's forest products and pulp and paper industry	End of second quarter (Q2) (Jan '21)
2. Physical and Chemical characterization and analysis of the solid waste including lignocellulose composition	End of second quarter (Q2) (Jan '21)

Activity 2: Biomass Separation and Pretreatment

Description: Using each of the major categories of above obtained solid waste (i.e. saw dust, flakes, fines, paper mill sludge) and the known biomass characteristics and composition, develop appropriate, innovative methods of separating the valuable biomass components including filtration, flocculation, centrifugation etc. For each of the biomass components i.e. saw mill fines, building on prior literature, develop appropriate pretreatment strategies that will help deconstruct the biomass and get access to renewable carbon namely cellulose, hemicellulose (sugars in biomass) and lignin (aromatic polymer). **Budgeted amount: $77,110**

Outcomes	Completion Date
3. Develop appropriate methods of separating the valuable biomass component from the solid waste	End of 3rd quarter (Q3) (Apr '21)
4. For each of the solid waste stream i.e. saw mill waste, develop appropriate pretreatment methods to deconstruct biomass and access the sugars and lignin	End of 4th quarter (Q4) (July '21)

Activity 3: Biomass Conversion to Value Added Sustainable Bioproducts

Description: Using the sugars and lignin from each of the solid waste stream, building on current scientific and technical knowledge base, develop most suitable innovative, biomass conversion approach to specific value added products including biofuels, biochemicals and biodegradable bioplastics. This could include cellulosic ethanol, biooil, biobutanol, furfural, bioplastics. This will include determining optimum process conditions, concentrations, yield, energy consumption and potential environmental impacts. **Budgeted amount: $77,110**

Outcomes	Completion Date
5. Develop most suitable biomass conversion approach for each solid waste stream to achieve specific value added products	End of 6th quarter (Q6) (Jan '22)
6. Determine the optimum process conditions, concentrations, yield, energy and potential environmental impacts.	End of 6th quarter (Q6) (Jan '22)

Activity 4: Techno-economic and Environmental Impacts Assessment for Biomass Conversion to Value Added Sustainable Bioproducts

Description: Using the information from above, we will conduct a process systems engineering analysis for the various biomass streams, and the separation, pretreatment and conversion approaches to value added products. For the given range of solid waste stream available, we will conduct a detailed process systems engineering analysis using Techno Economic Analysis (TEA) and Life Cycle Assessment (LCA) methods to determine the economic value and potential environmental impacts including greenhouse gas emissions, fossil fuel usage, landfill usage mitigated, energy utilization. **Budgeted amount $74,110**

Outcomes	Completion Date
7. Conduct a process systems engineering analysis for each of the biomass streams and conversion options to determine the economic value (TEA) for specific value added products	End of second year (Q8) (Jun '22)
8. Conduct an environmental impacts assessment (LCA) for each of the scenarios including greenhouse gas emissions, fossil fuels, landfill usage mitigated, energy utilization.	End of second year (Q8) (Jun '22)
9. Disseminate the findings to the forest products industry and the scientific community contributing to the knowledge base.	Each quarter (Q1:Q8) (throughout the project)
10. Work with industry partners in helping them implement potential solutions relevant to their specific manufacturing site	Q8 & follow-up upon project completion (Jun '22)

III. Project Partners and Collaborators: Liberty Paper, Becker, MN; PotlatchDeltic, Bemidji, MN; Norbord, Solway, MN; WestRock, St. Paul, MN; Lexington Manufacturing, Brainerd, MN and Coon Rapids, MN; Marvin Windows and Doors, Warroad, MN; SAPPI, Cloquet, MN; UPM-Blandin, Grand Rapids, MN; Verso Paper, Duluth, MN; Blandin Foundation, Grand Rapids, MN.

IV. Long Term Implementation and Funding This project clearly addresses an immediate and urgent need. Our industrial partners are actively seeking viable solutions and willing to share their expertise. If we are successful in developing optimal solutions for the waste streams, the industry partners will be interested in implementing the same in the near future. Please see the letters of support from our partners. The solutions developed here can also be widely applicable to other waste streams including municipal solid waste and can have long term broad ranging impacts across the State.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Shri Ramaswamy
Project Title: Converting Forest Products Industry Waste to Value-Added Bioproducts: Innovative approaches to reducing solid waste and GHG emissions and efficiency improvement in MN's forest products industry thus contributing to a viable forest bioeconomy in greater Minnesota

Project Budget: $309,000
Project Length and Completion Date: Two Year; End Date: 6/30/22
Today's Date: April 15, 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 285,000	$ -	$ 285,000
Prof. Ramaswamy, Shri, PI - No funding requested; will be responsible for overall planning, execution and implementaiton of the project			
Prof. Tschirner, Ulrike, Co-PI - .08 FTE (1 month) per year for two years- $40,000 (73.5% salary/26.5% fringe) - will be responsible for supervising the researchres, waste characterization, analysis, conversion strategies, process technology development			
Dr. Huang, Huajiang (contact research faculty funded on grants and contracts) - 1 FTE per year for 2 years - $143,000 (73.5% salary/26.5% fringe) - Will be responsible for expermental data analysis, process systems engineernig analysis, TEA, LCA, process development, design, modeling and simulation			
Graduate research assistant; 0.5 FTE per year - $97,000 (58% salary/42% fringe) - will be responsible for conducitng the waste analysis and characterization, biomass comversion experimental work, data collection and analysis, developing appropriate conversion methodolgies for value-added products			
Undergraduate research assistant - .08 FTE (164 hrs) per year (100% salary) - $5,000. Will work with other researchres helpign with the characterization, analysis, residue conversion experiments, data			
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/Supplies			
Laboratory Supplies - $12,000 - will include items such as chemicals, reagents, lab supplies, columns, solvents, gas cylinders for analytical characterization	$ 12,000	$ -	$ 12,000
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
This includes visiting with forest products industry manufacturing sites in Minnesota, collecting waste residue samples, periodic project review meetings at central locations, dissemination of project findings, presentation at review meetings and in-state conferences. Charges include mileage, hotel stays, per diem and other travel related expenses	$ 2,000	$ -	$ 2,000
Other			
Laboratory Services - Total of $10,000 for two years including chemical and physical properties characterization and analysis of soldi waste residues, intermediate products and final products characterization and analysis - these will be conducted in internal U of M facilities such as the analytical laboratories, characterization facilities and external laboratory service vendors	$ 10,000	$ -	$ 10,000
COLUMN TOTAL	$ 309,000	$ -	$ 309,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Unrecovered F&A	Secured	$ 149,000	$ -	$ 149,000
In kind: Participation in the project by forest products industry personnel throughout the project, project review meetings, providing samples and relevant data. Estimated total contributions - $24,000 - 10 hours per month among all the indsurty partners (~1 hr/mo/partner), rate: $100/hr.	Pending	$ 24,000	$ -	$ 24,000
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	**Amount legally obligated but not yet spent**	**Budget**	**Spent**	**Balance**
		$ -	$ -	$ -

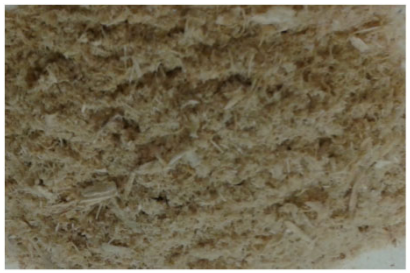
Forest Products Industry Waste to Value-Added Bioproducts

Bark

Chips

Dry Shavings/Trims

Saw dust/fines



Paper mill residues
(Recycled paper)

Paper mill residue
(Writing paper)

- **Biomass characterization**
- **Separation of biomass components**
- **Conversion to value-added products**
  - **biofuels, biochemicals**
  - **bioplastics, biochar**
- **Techno-economic and Life cycle analysis**
- **Waste and GHG emissions reductions**
- **Stronger MN's bio-economy**

Biooil

Fuel

Chemicals

Activated
Carbon

Bioplastic

Industry Partners: Marvin Windows and Doors, Warroad, MN; PotlatchDeltic, Bemidji, MN; Norbord, Solway, MN; Lexington Manufacturing, Brainerd, MN and Coon Rapids, MN; Liberty Paper, Becker, MN; WestRock, St. Paul, MN; SAPPI, Cloquet, MN; UPM-Blandin, Grand Rapids, MN; Verso Paper, Duluth, MN; Blandin Foundation, Grand Rapids, MN.

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Faculty PI and co-PIs with the Department of Bioproducts and Biosystems Engineering, University of Minnesota have number of years of industrial and academic experience and expertise in biomass characterization, biomass processing, development and implementation of biomass conversion technologies. Dr. Huajiang Huang, Research Assistant Professor, University of Minnesota has expertise in computer modeling, simulation, optimization, process systems engineering analysis and environmental assessment analysis. All three of the scientists will be working closely with the students, scientists at the analytical characterization and laboratory services facilities at the University of Minnesota and industry partners in the collection, characterization, analysis, development of appropriate conversion technologies and conducting techno-economic analysis and environmental performance assessment. We have a strong team of forest products industry partners and collaborators who will be contributing their expertise and provide advice and guidance on all aspects of the project from initiation to project completion. Please see attached letters of support.

Bioproducts and Biosystems Engineering have well established laboratories with wide ranging capabilities from bench scale to pilot scale. These include various biomass processing and conversion equipment including PARR reactors, M&K digesters, Wiley mill etc. and characterization and analysis including GC, HPLC, Light Scattering unit, DSC, etc.

In addition U of MN has numerous common purpose, general access laboratories for use by all graduate students and faculty in both the Minneapolis and St. Paul campuses including U of M Characterization Facility (http://www.charfac.umn.edu/), University Imaging Center (http://uic.umn.edu/), Rheology Lab, St. Paul analytical services lab, Biodale, Biotechnology Resource Center, Biofuels and Products Innovation Lab (BIL) and much more. An example of capabilities include spectrophotometers, HPLC, and GPC, freezers, centrifuges, Atomic Force Microscope, Scanning and Transmission Electron Microscope, TEM-Computed Tomography (TEM-CT), X-ray Computed Tomography (X-CT), Serial Block Face SEM, surface and thin-film analysis, Confocal Laser Scanning Raman Spectroscopy (CLSRS), light microscope, and x-ray diffraction and scattering, Mass Spectrometry (including GC-mass, MALDI-TOF and LC-simultaneous ESI and APCI mass spectrometry), Center for Mass Spectrometry and Proteomics and many others. Specific to this project laboratory facilities in the Center for Biorefining, Bioprocessing Lab, Biofuels and products Innovation Lab, Biodegradation and biodeterioration Lab, Composites and Advanced Materials Characterization Lab, Industrial Ecology Laboratory, to name a few, will be fully available to the students. In addition, adequate office and laboratory space is available in the BBE department (both in the BBE north Kaufert Lab and the BBE south BAE Building) for graduate students and other researchers. Computer labs with adequate computing resources including the Minnesota Supercomputing Institute and Digital Technology Center are also available.