**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)**

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| **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**

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| **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**

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| **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**

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| **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.