**PROJECT TITLE: Produce marketable liquid fuels from plastic wastes**

**I. PROJECT STATEMENT**

Solid wastes, particularly non-biodegradable plastic wastes, are an immense and growing environmental problem. Of the over 100 million annual tons of plastic waste, less than 10% is recycled. Much of it makes its way into rivers and disposes into the ocean, landfills, or is incinerated. By converting plastic wastes to liquid fuels, wastes can be intercepted and re-used, greatly reducing potential environmental and ecological impacts. The total conversion ***economic opportunity is over $29 billion*** ***in the US alone***, spurring the phrase “landfills are the future goldmine”. This project is designed to evaluate and develop conversion technology for production of high quality and ***marketable liquid fuels from municipal solid wastes*** and hence ***reduce solid wastes and protect the environment***. The project addresses *Priority E: Air Quality, Climate Change, and Renewable Energy*.

To further illustration the significance of the problems with plastic waste, consider these facts:

* Recent studies show ***microplastics***, which are tiny plastic fragments that wear off of synthetic clothing, fall off decomposing plastic bags and bottles, and are manufactured into some products, ***pollute lakes and rivers***, and ***endanger wild lives and biodiversity***.
* Plastics contain ***toxins*** that are linked to cancer, birth defects, immune-system problems, and childhood developmental issues.
* In addition to contaminating ocean waters, ***94 percent of tap-water samples in the United States contained plastic fibers***. ***Plastics can also disturb forest and clog waterways***.
* Plastic wastes are a significant economic burden to waste treatment infrastructure.

Conversion of waste plastic to high-quality fuels and chemicals still has many ***technical, economic, and environmental challenges***. Briefly, current conversion processes have low usable fuel yields, low fuel quality, and are economically infeasible. These issues significantly impact the viability of converting waste plastics into usable and marketable products and must be addressed before the technology can be commercialized.

LCCMR provided support to our pyrolysis project in 2007 funding process (M.L. 2007) to develop microwave assisted pyrolysis (MAP) of biomass. LCCMR subsequently funded a number of projects that involved development of microwave assisted pyrolysis of biomass. As a result, the technology has evolved from moderate heating rate processing to fast microwave assisted pyrolysis (fMAP) that can be used to convert biomass to liquid and gaseous fuels and biochar. ***Our preliminary research indicated that*** ***plastics are an excellent feedstock for liquid fuel production*** because they have high hydrocarbon content and no or little oxygen content. We also found a relatively large fraction of wax among the products from pyrolysis of plastics without adequate catalysts. ***The liquid product contains hydrocarbons found in gasoline and diese***l. We are ready to tweak the fMAP for plastics and evaluate its environmental and economic impacts.

The ***overall*** ***goal*** of our research program is to develop and commercialize plastic-to-fuel (PTF) technology that will prevent plastic wastes from polluting Minnesota lands and waters and at the same time produce marketable products. The efforts planned for this project are to go beyond proof of concept and develop process specifically for plastic wastes as the feedstock. The ***specific objectives*** of the project include:

1. Process development: study of effects of processing temperature, heating rate, catalysts, methods of feeding plastics, presence of biomass on product yield and quality; optimization of the process.
2. Impact assessment: preliminary input-output analysis to provide assessment of economic potential and environmental and ecological benefits.

**II. PROJECT ACTIVITIES AND OUTCOMES**

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| **Activity 1:** *Develop and investigate processes for converting plastic wastes to high quality liquid fuels*  Plastic wastes may come in different compositions. Some are pure plastics containing a single type or mixture of different plastic materials from manufacturing sources; some contain non-plastic materials such as those from municipal solid wastes. We will first test different feedstocks using standard process with our lab experimental apparatus. The results from the initial tests will guide our further development and investigation of processes designed for specific feedstock compositions. The key processing parameters and conditions to be investigated and adjusted are heating rate, temperature, feeding rate, and catalysts. The yields of liquid, gas, and char fractions will be measured; the chemical composition and energetic properties of the liquid will be determined to evaluate the fuel quality. These planned activities are expected to generate information that will help us understand the relationships between processing variables and product yield and quality, laying the foundation for further R&D to move the technology to commercial sectors.  **ENRTF BUDGET: $200,000** | | |
| **Outcome** | **Completion Date** |
| *Collection and characterization of plastic wastes* | *09/30/2020* |
| *Initial test of microwave assisted pyrolysis of plastic wastes* | *12/31/2020* |
| *Process development and investigation* | *12/31/2022* |
| *Evaluation of the process and product yield and quality* | *12/31/2022* |
| **Activity 2:** *Evaluate the potential economic, environmental and ecological impacts of the proposed technology*  For this small project, we plan to conduct preliminary studies to provide big pictures of the potential economic, environmental and ecological impacts of the plastic-to-fuel technology. Additional data on mass and energy balance will be collected. Greenhouse gas emission during the process will be monitored. An input-output model will be used for economic analysis. The energy consumption, greenhouse gas emission, and waste reduction will be considered in the assessment of environmental and ecological impacts of the technology.  **ENRTF BUDGET: $183,000** | | |
| **Outcome** | **Completion Date** |
| *Collection of mass and energy balance data* | *12/31/2022* |
| *Monitoring of greenhouse gas emission* | *12/31/2022* |
| *Estimate of potential reduction in plastic waste and production of valuable products* | *06/30/2023* |
| *Preliminary assessment of economic, environmental, and ecological impacts* | *06/30/2023* |

**III. PROJECT PARTNERS:**

**A. Project team:**

Paul Chen (BBE, UMN), Roger Ruan (BBE, UMN)

**B. Partners NOT receiving ENRTF funding**

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| --- | --- | --- | --- |
| **Name** | **Title** | **Affiliation** | **Role** |
| John Snyder | President | Minnesga | Help with system development and evaluation |

**IV. LONG-TERM- IMPLEMENTATION AND FUNDING:**

New scientific knowledge and experience on microwave assisted pyrolysis of plastic wastes will be acquired through research. Processes for specific plastic wastes will be developed. The potential economic, environmental and ecological impacts will be presented to the stakeholders to raise their awareness and attract their support. We will seek industry partners and private, state, and federal funding to further develop and eventually commercialize the technology.

**V. TIME LINE REQUIREMENTS:**

This project is planned for 3 years beginning July 1, 2020 and ending June 30, 2023. Most of the first 30 months will be focused on the development and understanding of the processes, and much of the last 6 months will be focused on assessment of the impacts of the technology.