**PROJECT TITLE: Pilot Scale Anaerobic Digester for Mixed Wastes**

**I. PROJECT STATEMENT**

Increasing organic wastes in urban and rural areas pose significant threats to the environment but also present economic opportunities because they contain large amounts of potentially recoverable nutrients and energy. Animal manure in the rural areas is traditionally used for land application. While no special effort is needed to collect manure from concentrated animal feeding operations (CAFOs) for treatment, household food wastes are usually not separated from municipal solid wastes (MSW). More than 50% of MSW goes to landfill, which causes large scale contamination of soil, water and air, is a significant contributor to greenhouse gas emissions, and leaves huge potential economic values uncaptured. Interestingly, the number of curbside organic wastes (particularly food wastes) collection programs has increased from 79 in 2014 to 148 in 2017, or 87 percent. Hennepin County started curbside organic waste collection a few years ago. This opens a great opportunity for food wastes utilization.

Anaerobic digestion (AD) of organic wastes is a demonstrated technology that can contribute significantly to renewable fuel production. Unfortunately, AD has not been economically competitive with fracked natural gas supplies, until now. The use of AD biogas for electrical power generation may still be at an economic disadvantage compared with fracked natural gas (or wind turbines for power generation). But using refined biogas, as Renewable Natural Gas (RNG) for vehicular transportation fuel is now receiving economically viable credits as a “low carbon fuel”, particularly on the west coast of the United States. The time to grow the “RNG” industry in the United States has arrived. Organic wastes to RNG via AD is an established technology that is poised to contribute to the growing response to the climate change challenge, and hence we can now focus on converting the existing AD technology to commercial scale as quickly as possible. However, challenges remain when adapting any system to given feedstock on a commercial scale. For example, Minnesota is a leading turnkey producer and generates a huge amount of turkey litter. Like food wastes, turkey litter is relatively dry compared with dairy and swine manure. Digestion of these wastes can be quite different.

**The purpose of this proposed pilot system is to generate hard data to support a commercial project that can serve as a successful example of implementing AD systems in Minnesota. Specifically, the resulting data will be used to confirm the design basis of the AD process and system and scale up the process and system.** For the proposed project, work is needed in two specific areas:

1. The reaction (process) characteristics and yields as a function of feedstock (substrate) and key process parameters need to be documented. Feedstock may include organic wastes such as turkey litter, liquid dairy manure, and food wastes. Experimental data will be collected in order to answer following questions for the purpose of adapting an AD system for mixed organic wastes:

* What is the “sensitivity” of bio-methane production to the variability of the ratio of these substrates being fed to an AD system?
* As the mixture of organic wastes varies, how can the production of bio-methane by optimized?
* What is the biological stability of the anaerobic system, if run as a mesophilic versus thermophilic system,

1. The effluent from the digester needs to be characterized and documented as they have the potential for use as liquid and solid fertilizers to improve the financial outlook of operating an AD system. Questions to be answered include:

* What is the remaining nutrient level in the biomass;
* What is the ease of separation of the biomass from the filtrate?
* Can the biomass be handled in standard agricultural equipment for spreading this organic fertilizer onto agricultural land?
* What are the remaining soluble nutrients in the aqueous effluent after filtration of the biomass?
* How can the aqueous effluent be used as a source of crop nutrients and irrigation?

**II. PROJECT ACTIVITIES AND OUTCOMES**

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| **Activity 1:** Design, build, and evaluate a pilot-scale anaerobic digester system  The pilot scale anaerobic digester will be 40 Liters in volume, with a 20 day HRT, built in the UMN Dept. of Biosystems Engineering. Mixed organic wastes (food and animal manures) will be fed to the system at varying ratios. The biogas generated from the wastes will be converted to bio-methane (RNG). We will measure the biogas and bio-methane production, also filter the biomass from the digester effluent, and analyze the biomass filter-cake and filtrate to evaluate the chemical content of each. As feed substrate ratios to the digester are changed, note any changes in the volume of biogas and bio-methane generated, and the composition and handling ability of the effluent streams. Share the organic fertilizer data with commercial fertilizer suppliers in the area, and encourage their participation in the project team. Record and document all the operating data, resulting biogas, bio-methane, biomass and filtrate variations, to be used to fine-tune the design of the commercial system.  **ENRTF BUDGET: $200,000** | | |
| **Outcome** | **Completion Date** |
| 1. *Design and construct the pilot anaerobic digester with proper mixing and biogas cleaning* | *06/30/2021* |
| 1. *Test and optimize the process and system for different substrate mixtures;* | *12/31/2021* |
| 1. *Collect technical data to characterize the process and system and provide scale up information* | *12/31/2022* |
| 1. *Analyze the effluent for potential use of liquid and solid fertilizers* | *12/31/2022* |

**Activity 2:**System evaluation and demonstration

Utilize the above pilot plant data as a basis to scale up to the commercial anaerobic digester plant design. Work with, and advise the commercial plant design team, as needed to incorporate the pilot plant results to guide the design of the commercial plant.

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| **ENRTF BUDGET: $50,000** | | |
| **Outcome** | **Completion Date** |
| 1. *Evaluate technical, economic, and environmental performance of the system* | *06/30/2023* |
| 1. *Share data with the commercial project design team* | *06/30/2023* |
| 1. *Demonstrate the system to stakeholders* | *06/30/2023* |

**III. PROJECT PARTNERS:**

**A. Project team:**

Min Addy (BBE, UMN), Roger Ruan (BBE, UMN), Paul Chen (BBE, UMN), Kirk Cobb (BBE, UMN)

**B. Partners NOT receiving ENRTF funding**

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| **Name** | **Title** | **Affiliation** | **Role** |
| Raymond Davy | Owner, Project Manager | Agri-Waste Energy Operations, Inc. | Project advisor |

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

The proposed research is important to adapting AD systems to Minnesota waste management landscape. The data collected will be used for installation and operation of an AD system in the eastern Minnesota area. The funding for the commercial project will be raised by a private company.

**V. TIME LINE REQUIREMENTS:**

This is a three years project. A pilot scale anaerobic digester system will be designed and built, and operated stably within the first 18 months. Technical data will be collected in the next 12 months. In the remaining 6 months, we will share pilot data with commercial project team and discuss development of the commercial system.