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

Project Title: **ENRTF ID: 191-E**

Pilot Scale Anaerobic Digester for Mixed Wastes

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

Sub-Category:

Total Project Budget: $ 250,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

To develop a pilot-scale anaerobic digester and generate information for designing and building a commercial anaerobic digester in eastern Minnesota to produce renewable natural gas from organic wastes

Name: Min Addy

Sponsoring Organization: U of MN

Job Title: Prof.

Department: Bioproducts and Biosystems Engineering

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Location:

Region: Statewide

County Name: Statewide

City / Township: Saint Paul

Alternate Text for Visual:

Process flow diagram that taking organic wastes from difference sources through anaerobic digestion to produce biogas and renewable natural gas (RNG)

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

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,
2) 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

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
Design and construct the pilot anaerobic digester with proper mixing and biogas cleaning	*06/30/2021*
Test and optimize the process and system for different substrate mixtures;	*12/31/2021*
Collect technical data to characterize the process and system and provide scale up information	*12/31/2022*
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.

ENRTF BUDGET: $50,000

Outcome	Completion Date
Evaluate technical, economic, and environmental performance of the system	*06/30/2023*
Share data with the commercial project design team	*06/30/2023*
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

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.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Min Addy
Project Title: Pilot Scale Anaerobic Digester for Mixed Wastes
Organization: University of Minnesota
Project Budget: $250,000
Project Length and Completion Date: 3 years - June 30, 2023
Today's Date: 4/11/19

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 197,000	$ -	$ 197,000
Min Addy, PI, .16 FTE, 3 yrs, $40,000, 73,5% salary/26.5% fringe - leading and managing lab and field testing project, leading demontration, supervising graduate student			
Roger Ruan, Co-PI, 0.04 FTE, $33,000 3 years, 73.5% salary/26,5% fringe - leading lab and field testing project, demonstration, supervising graduate student			
Paul Chen, Co-PI, 0.04 FTE, $16,000, 73.5% salary/26.5% fringe - leading lab and field testing project, demonstration, supervising graduate student			
Research Associate, 0.5 FTE, $108,000, 73.5 salary/26.5% fringe, conducting R&D, operations, demontration, data anaylsis			
Professional/Technical/Service Contracts			
		$ -	$ -
Equipment/Tools/Supplies			
Supplies, instruments, non-capital equipment	$ 45,000	$ -	$ 45,000
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
Travel to collect samples in fields and demonstration site	$ 3,000	$ -	$ 3,000
Other			
Chemical analysis, equipment calibration, maintenance and repairs	$ 5,000	$ -	$ 5,000
COLUMN TOTAL	$ 250,000	$ -	$ 250,000

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	$ 135,000	$ -	$ 135,000

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

Pilot Scale Anaerobic Digester for Mixed Wastes

Food Wastes

Animal Manures

Poultry Litter

Single or mixed substrate

Pilot Scale - Anaerobic Digester

Biogas: Convert to Renewable Natural Gas

Effluent Filtration

Biosolids for compost

Liquid fertilizer

Project Manager Qualifications and Organization Description

Dr. Min Addy, a Research Associate Professor in the Department of Bioproducts and Biosystems Engineering (BBE), University of Minnesota (UofM), will serve as the project manager of the proposed project. In the past ten years, Dr. Addy has been focusing on research on converting waste resources to renewable fuels, feed, and other valuable bioproducts. The processes she developed include waste to fuel conversion, anaerobic digestion, algae biofuel production, aquaponics and hydroponic for waste treatment and vegetable production, and microwave assisted biochar and biofuel production. Prof. Addy is an active researcher and involved in multiple LCCMR, USDA, DoD, DoE, Xcel Energy, and MnDrive funded projects. At the same time Dr. Addy has been managing the microalgae lab, thermochemical conversion lab at BBE, and a hydroponic growth facility at UofM Greenhouse. She also supervised over one hundred of under/graduate students, post-doctors, visiting scholars, and summer students and has published over 80 papers in refereed journals, and many meeting papers and reports, and holds 3 US patents.

As a member of the Center for Biorefining, a University of Minnesota research center, Professor Addy works closely with Professors Roger Ruan and Paul Chen, in coordination of the efforts and resources to conduct exploratory fundamental and applied research and provide education on bioenergy, biochemicals and biomaterials; stimulate collaboration among the University researchers, other public sector investigators, and private investigators involved in biobased production technology development; promote technology transfer to industries; and foster economic development in rural areas. The Center's research programs are founded by DOE, USDA, DOT, DOD, LCCMR, IREE, Xcel Energy, and other federal and state agencies, NGOs, and private companies. The Center is equipped with state-of-the-art analytical instruments, and processing facilities ranging from bench to pilot scale. In particular, they have the capability to develop various bioreactors for different purpose and the means to evaluate related processes.