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

Project Title: **ENRTF ID:** **083-B**

Technology for Energy-Generating Onsite Industrial Wastewater Treatment

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 474,939

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

Summary:

We will develop "off the shelf" technology to treat industrial wastewater onsite, turning pollutants into hydrogen and methane for energy. This will lead to water quality benefits and cost savings.

Name: Paige Novak

Sponsoring Organization: U of MN

Job Title:

Department: College of Science and Engineering

Address: 122 Civil Engineering Building, 500 Pillsbury Drive SE
Minneapolis MN 55455

Telephone Number: (651) 808-0859

Email novak010@umn.edu

Web Address:

Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The figure shows how the system will treat wastewater for possible reuse, generate energy, and save energy for community-level wastewater treatment

_____ Funding Priorities _____ Multiple Benefits _____ Outcomes _____ Knowledge Base

_____ Extent of Impact _____ Innovation _____ Scientific/Tech Basis _____ Urgency

_____ Capacity Readiness _____ Leverage _______ TOTAL _____%

PROJECT TITLE: TECHNOLOGY FOR ENERGY-GENERATING ONSITE INDUSTRIAL WASTEWATER TREATMENT

I. PROJECT STATEMENT

In Minnesota the food- and beverage-processing industry, including dairies, malting plants, potato processing facilities, and breweries, is vibrant and provides economic opportunities in **both urban and greater Minnesota communities**. **These industries are water intensive and many do not treat their wastewater onsite**. Instead, they discharge their untreated wastewater, typically 20-100 times "stronger" or more concentrated than municipal wastewater, to a centralized municipal treatment plant. As a result:

- The industry is required to pay fees to the municipality to discharge the water to the municipal treatment plant, and
- The municipality has to expend energy to treat the (much stronger, more challenging, and potentially disruptive) industrial wastewater.

Our goal is to expand previous LCCMR-funded research to enable widespread onsite industrial wastewater treatment that turns pollutants into hydrogen and methane fuels and provides benefits to municipalities in the form of more predictable and easier wastewater treatment and lowered treatment costs.

A previous successful LCCMR project formed the basis for this research, resulting in the development of first-generation technology that we have since improved upon. This new technology

- Is designed to be installed onsite at food- and beverage-processing industry facilities,
- Consists of two reactor stages, one to turn pollutants into hydrogen and a second to clean the water further and turn remaining pollutants into methane,
- Treats the wastewater using bacteria that are encased (or encapsulated) in non-toxic gel-like beads,
- Easily retains the beads within the reactor and protects the bacteria within the beads,
- Turns pollutants in the wastewater into hydrogen and methane by allowing the encapsulated bacteria to "eat" the pollutants in the wastewater much as we eat food, "exhaling" hydrogen and methane. The hydrogen and methane are used directly onsite as fuels for energy generation.

In addition, this new technology improves upon other onsite treatment options by being very compact, and therefore less expensive to install, and by not only creating energy from pollutants in the waste, but requiring much less energy to operate when compared to competing technologies.

After onsite treatment of this very concentrated industrial wastewater, the treated wastewater is then discharged to the municipal wastewater treatment plant. Because the industrial waste is pre-treated, it should not disrupt their operation and will be much easier for the municipality to manage and further treat, requiring less energy and cost to do so. All of this should result in water quality and quantity benefits.

Unfortunately, although we have demonstrated successful deployment of the technology with real wastewater, in its current form, this technology is not easily scaled up and each new application (*e.g.*, breweries vs. dairies) requires customization in terms of the bacteria within the beads, the type of beads made, their size, and their number. All of this increases the cost of the technology and limits its use. The proposed research would advance this technology to the point of being "off the shelf." We will create an adaptable bacterial community that can be encapsulated in beads and used with a wide variety of wastewaters from the food- and beverage-processing industry. We will determine the optimal bead material to allow for bacterial growth within the beads. We will test the system at a pilot scale with multiple wastewaters. We will perform system optimization to decrease energy use (pumping, etc.) and maximize energy production.

II. PROJECT ACTIVITIES AND OUTCOMES

ACTIVITY 1: Develop an adaptable bacterial community and refine the encapsulating chemistry to enable reliable treatment of a range of industrial wastewaters

Description: A mixed bacterial community will be developed and tested that will grow within the encapsulation matrix (beads) and consume the wide variety of compounds in different wastewater streams. The encapsulation matrix will be optimized to protect the bacteria inside, provide space for them to grow, and enable the bacteria within the encapsulation matrix to access the variety of wastes that need to be consumed. The robustness of the treatment will be tested with a variety of wastewaters from food- and beverage-processing industries.

ENRTF BUDGET: $179,070

Outcome	Completion Date
1. Understand how a mixed hydrogen-producing community develops and grows when treating a variety of wastewaters	*01/31/22*
2. Understand how a mixed methane-producing community develops and grows when treating a variety of wastewaters	*06/31/22*
3. Demonstration of the two-stage hydrogen- and methane-producing technology with a range of wastewaters in the laboratory	*10/31/22*

ACTIVITY 2: Pilot scale testing and design optimization of the wastewater treatment system.

Description: Using the microbial communities developed in Activity 1, the technology will be tested at the pilot scale at various industries (potato processing, candy manufacturing, brewery). A full evaluation of the design and operation of the system will be used to determine how to best maximize hydrogen and methane production while minimizing energy and equipment costs (e.g., pumping, gas collection).

ENRTF BUDGET: $295,869

Outcome	Completion Date
1. Scale up and demonstration of the technology at a pilot scale at multiple industries	*01/31/23*
2. Optimization of system design and energy efficiency	*6/30/23*

III. PROJECT PARTNERS AND COLLABORATORS:

Our primary project partners are Minnesota Department of Employment and Economic Development (DEED) and Metropolitan Council Environmental Services (MCES). Our team has been assembled to include expertise from the University of Minnesota in water treatment and energy generation (Novak and Arnold-Civil, Environmental, and Geo- Engineering; Wright-Mechanical Engineering). We have been working as a team to bring this novel technology to fruition.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

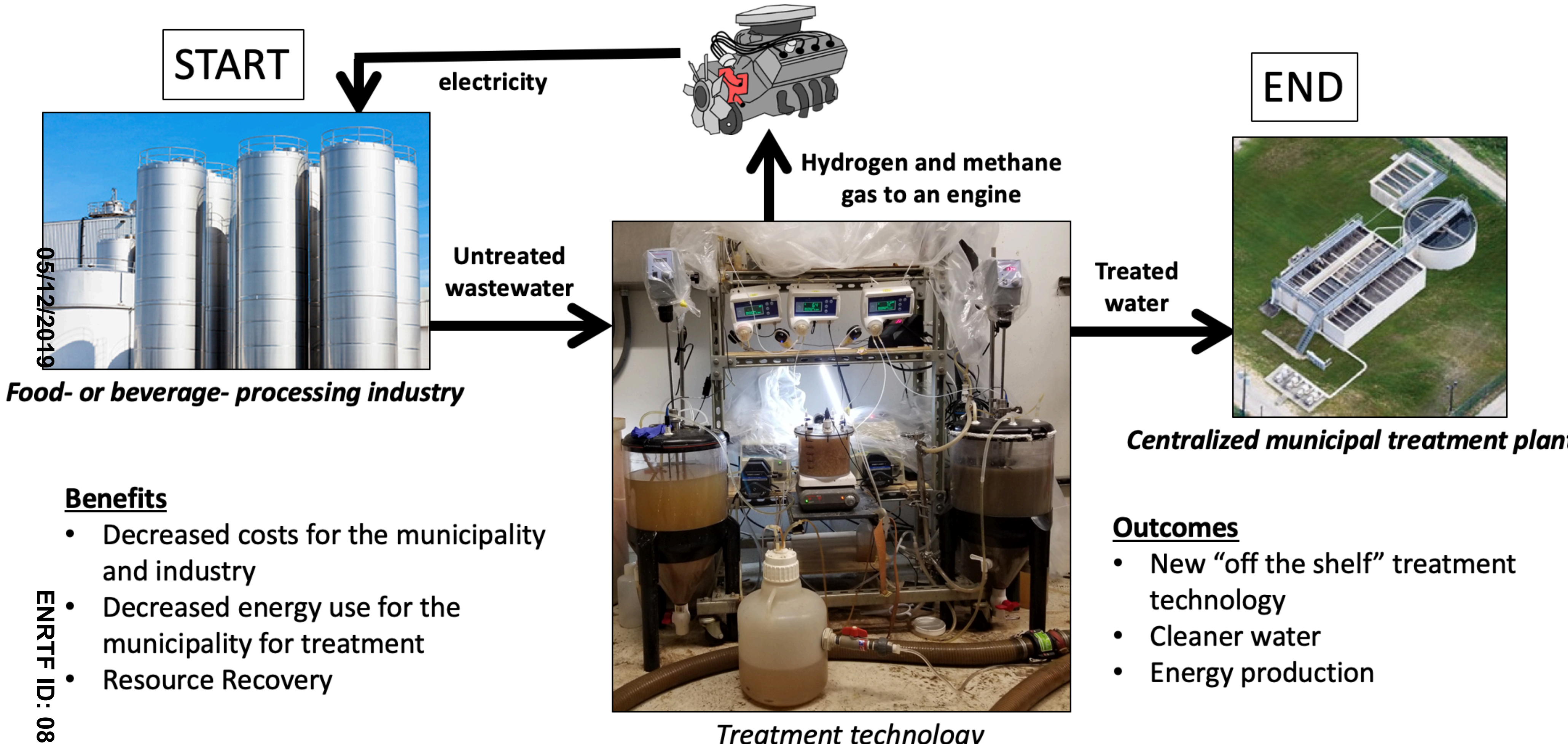
We have been pursuing National-scale funding for the project and will continue to do so. The project is currently being tested at a small pilot-scale at the Fulton Brewery. We have worked with a team at the Carlson School of Management to determine realistic value propositions for the technology. If a truly robust system can be developed and tested, communication efforts through MN DEED, MCES, and trade organizations will be used to further our implementation activities. We will work with the Venture Center at the University of Minnesota on additional implementation efforts.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Paige Novak
Project Title: TECHNOLOGY FOR ENERGY-GENERATING ONSITE INDUSTRIAL WASTEWATER TREATMENT
Organization: University of Minnesota
Project Budget: $474,939
Project Length and Completion Date: 3 years, June 30, 2023
Today's Date: April 12, 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	**Budget**	**Amount Spent**	**Balance**
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 412,739	$ -	$ 412,739
Novak, PI (6% time per year for three years, salary 74% of cost, fringe benefits 26% of cost). Overall project supervision, microbial encapsulation and monitoring, provide guidance on the lab- and pilot-scale reactor construction and operation. Total estimated cost is $51,513.			
Arnold, Co-PI (6% time per year for three years, salary 74% of cost, fringe benefits 26% of cost). Encapsulant chemistry modification, provide guidance on the on the lab- and pilot-scale reactor construction and operation. Total estimated cost is $51,567.			
Wright, Co-PI (6% time per year for three years, salary 74% of cost, fringe benefits 26% of cost). Energy production and use optimization, provide guidance on the on the on the lab- and pilot-scale pilot-scale reactor construction and operation. Total estimated cost is $34,330.			
One Postdoctoral Researcher (one FTE per year for two years, salary 80% of cost, fringe benefits 20% of cost). Will focus on the lab- and pilot-scale reactor construction and operation. Total estimated cost is $126,487.			
One Graduate Research Assistant (50% FTE per year for three years, salary 58% of cost, fringe benefits 10% of cost, tuition 32% of cost). Will focus on the development of a flexible microbial community for encapsulation and the encapsulant chemistry. Total estimated cost is $148,841.			
Equipment/Tools/Supplies			
Laboratory supplies, services, and analytical costs (includes, but is not limited to, chemicals for all analyses, supplies to maintain analytical equipment, supplies for reactor construction, including pilot reactor construction, pumps for lab- and pilot-scale systems, monitoring equipment for pilot-scale systems, controllers for pilot-scale systems, gas extraction membranes, microbial analysis costs, analytical fees). These are all required and standard costs.	$ 60,200	$ -	$ 60,200
Travel expenses in Minnesota			
Travel costs for sample collection, and pilot system set-up and monitoring.	$ 2,000	$ -	$ 2,000
COLUMN TOTAL	$ 474,939	$ -	$ 474,939

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	**Status (secured or pending)**	**Budget**	**Spent**	**Balance**
Non-State: None		$ -	$ -	$ -
State: None		$ -	$ -	$ -
In kind: Because the project is overhead-free, laboratory space, electricity, and other overhead costs are provided in kind. The University of Minnesota overhead rate is 54% (equivalent to $230,010).	Estimated	$ -	$ -	$ -
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	**Amount legally obligated but not yet spent**	**Budget**	**Spent**	**Balance**
Active: M.L. 2017, Chp. 96, Sec. 2, Subd. 04b		$ 450,000	$ 208,594	$ 241,406
Completed: M.L. 2014, Chp. 226, Sec. 2, Subd. 03d; M.L. 2017, Chapter 96, Section 2, Subdivision 18		$ 500,000	$ 454,288	$ 45,712
Completed: M.L. 2014, Chp. 226, Sec. 2, Subd. 03b		$ 279,000	$ 277,935	$ 1,065

Onsite wastewater treatment from food- and beverage-based industries will lead to clean water, energy production, and reduced costs.



Project Manager Qualifications and Organization Description

Paige J. Novak
Professor and Joseph T. and Rose S. Ling Chair of Environmental Engineering, Department of Civil, Environmental, and Geo- Engineering, University of Minnesota

B.S., Chemical Engineering, 1992, The University of Virginia, Charlottesville, VA.
M.S., Environmental Engineering, 1994, The University of Iowa, Iowa City, IA.
Ph.D., Environmental Engineering, 1997, The University of Iowa, Iowa City, IA.

Dr. Paige Novak will be responsible for overall project coordination. She has been studying the biological treatment of water and wastewater for over 20 years. Recent work has focused on the generation of energy from high-strength wastewater and the degradation of pollutants in wastewater to facilitate water reuse. She and Dr. William Arnold completed an LCCMR-funded project on the generation of energy from high-strength wastewater and obtained a patent and have an additional provision patent filed on that work. They have also published several high-profile papers related to that work.

William Arnold (Distinguished McKnight University and Joseph T. and Rose S. Ling Professor, Civil, Environmental and Geo- Engineering) is an expert in chemical fate, transport, and water treatment. For the past 10 years he has been a pioneer in the development and modeling of polymer films for chemical containment.

Natasha Wright (Assistant Professor, Mechanical Engineering) focuses on the design and system optimization of decentralized water treatment systems, with a specialty in membrane-based separation processes. Over the last 6 years, she has piloted combined energy generation / water treatment systems in the United States, India, and Gaza.

Organization Description
The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States (http://www1.umn.edu/twincities/01_about.php). The laboratories and offices of the PI and co-PIs contain all of the necessary fixed and moveable equipment and facilities needed for the proposed studies.