

**Environment and Natural Resources Trust Fund  
2014 Request for Proposals (RFP)**

---

**Project Title:**

**ENRTF ID: 125-E**

Clean Water/Renewable Energy from Beet Waste/Manure

---

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

---

**Total Project Budget:** \$ 403,685

**Proposed Project Time Period for the Funding Requested:** 3 Years, July 2014 - June 2017

**Summary:**

Sugar beet processing wastewater and pig manure, the two major pollutants to Minnesota water, can be used together to produce bioenergy (\$9.72 million) and a crop fertilizer (\$5 million) annually.

---

**Name:** Jun Zhu

**Sponsoring Organization:** U of MN

**Address:** 35838 120th Street  
Waseca MN 56093

**Telephone Number:** (507) 837-5625

**Email:** zhuxx034@umn.edu

**Web Address:**

---

**Location**

**Region:** Statewide

**County Name:** Statewide

**City / Township:**

---

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



## Environment and Natural Resources Trust Fund (ENRTF)

### 2014 Main Proposal

**Project Title:** Clean water/renewable energy from beet waste/manure

**PROJECT TITLE:** Clean water/renewable energy from beet waste/manure

#### I. PROJECT STATEMENT

Minnesota is ranked #2 in hog production and #1 in sugar beet production in the nation, which generate about 11 million tons of pig manure and over 1 million tons of sugar processing wastes annually. Up to this date, there are no cost-effective methods available to deal with these waste streams environmentally and resourcefully other than land application, which, over the years, is linked to environmental issues in many places in the state due to the buildup of nutrients (nitrogen and phosphorus) in the soil receiving these two wastes, increasing the potential of surface and ground water pollution caused by nutrients runoff and/or leaching from overloaded soils. In early 2012, Minnesota became the nation's first test site for a novel federal program designed to stem the flow of agricultural pollution to water resources (<http://phys.org/news/2012-01-strategy-farm-runoff-minnesota.html>). Needless to say, this sounds an alarm that immediate actions must be taken to treat these wastes. However, treatment alone is not only expensive but fails to recover the resource values of both waste streams. In fact, the two wastes, i.e., pig manure and sugar beet processing wastewater (containing molasses), have complementary nutrients, one having residual sugar which is an ideal carbon source highly needed in biological processes such as fermentation and anaerobic digestion, while the other having all the other nutrients but sugar for biological activities. Therefore, this proposal is aimed at using these two waste streams with complementary nutrients to produce bioenergy and reduce their negative impact on water resources. There are two sugar beet processing companies in MN (American Crystal Sugar Company and Southern Minnesota Sugar Cooperative) that produce all the sugars (the former has three facilities located in East Grand Forks, Moorhead, and Crookston, while the latter has one facility located in Renville, MN). There are also a total of around 4700 hog farms across the state but concentrated in the southern counties in Minnesota (see the attached concentration map). The proposed research project will address the environmental issues and produce bioenergy as indicated below. The proposed system flow chart is shown in figure 1 in the appendix.

- Land application of over 1 million tons of sugar processing wastewater threatens water resource
- Land application of over 11 million tons of pig manure increases surface and groundwater pollution
- \$10 million can otherwise be saved for sugar beet processors annually for wastewater treatment
- Bio-electricity of 143 million kWh (\$9.72 million) can be produced yearly from the two waste materials (at a ratio of 5 (pig manure) to 1 (sugarbeet wastewater))
- An alternative use of the produced hydrogen and methane is to produce "biohythane", which is a better combustion engine fuel that can cut down on greenhouse gas emission by 57% when used in combustion engines (equivalent to 27 million gallons of diesel that can be produced annually); biohythane is a mixture of 10% hydrogen, 60% methane, and 30% carbon dioxide, which can be used for combustion engines on the farm, such as tractors, etc.
- 15,560 tons of ammonia/phosphate fertilizer (struvite) will also be produced annually (\$5 mil value)

#### II. DESCRIPTION OF PROJECT ACTIVITIES

**Activity 1:** (Lab study for hydrogen, methane, struvite reactors, and scrubbers) **Budget: \$ 265,022**

Lab-scale hydrogen and methane reactors will be built for co-fermenting sugar wastewater with pig manure for hydrogen and methane production. The reactors will be tested using 5 ratios of manure to sugar wastewater based on manure total solids to the molasses content in the wastes to determine statistically optimal combinations. For the struvite reactor, the effluent from the methane digester will be used as the influent. For gas cleaning, two identical chemical scrubbers will be built and tested to remove carbon dioxide from the offgas and purify hydrogen and methane. The captured carbon dioxide may be used as nutrient for greenhouse plants. The proposed treatment system is aimed at continuous production of hydrogen, methane, and struvite from the two waste streams contemplated in this project and the information from the lab-scale experiments will provide key information for designing the pilot-scale system for large applications. Since the amount of sugar beet processing wastewater needed is small, transporting it to swine farms is deemed inexpensively.



**Environment and Natural Resources Trust Fund (ENRTF)**

**2014 Main Proposal**

**Project Title:** Clean water/renewable energy from beet waste/manure

<b>Outcome</b>	<b>Completion Date</b>
1. Lab-scale reactors construction and system setup (\$65,000)	Oct. 31, 2014
2. Optimal running conditions for the reactors determined (\$55,000)	June 30, 2015
3. Optimal conditions for gas cleaning chemical scrubbers determined (\$35,022)	Dec. 31, 2015
5. Optimal conditions for struvite reactor determined (\$50,000)	June. 30, 2016
6. The complete lab-scale system assembled and pilot-scale system built (\$60,000)	Sept. 30, 2016

**Activity 2 :** (Pilot-scale system installation and evaluation)

**Budget: \$ 138,663**

With the respective optimum operating conditions determined for all the component units of the system for co-treating pig manure and sugar wastewater, the entire treatment system will be assembled and installed at the University of Minnesota Southern Research and Outreach Center at Waseca, MN for evaluation based on the following three criteria.

- The system performance in cutting organic pollutants of the two wastewaters will be examined (the throughput capacity and removals of nutrients and solids).
- The net energy recovery by the system will be evaluated based on the energy produced less consumed.
- The costs and benefits of constructing and operating the pilot-scale system will be calculated based on the potential revenues (biogases and fertilizer produced) and the initial capital investment.

<b>Outcome</b>	<b>Completion Date</b>
1. Pilot-scale system installation and testing (\$83,200)	Nov. 30, 2016
2. System performance in waste treatment and energy production determined (\$55,463)	June 30, 2017

**III. PROJECT STRATEGY**

**A. Project Team/Partners**

Project Leader: Jun Zhu, Professor in the Bioproducts & Biosystems Engineering Department, University of Minnesota. Dr. Zhu will be responsible for carrying out the development and evaluation of the proposed treatment system and will be receiving funds on behalf of the University of Minnesota.

Project partner: Kevin Hennessy, Minnesota Department of Agriculture. Kevin will help organize activities for technology and information dissemination among pig and sugar farmers in Minnesota. No funds are requested.

**B. Timeline Requirements (3 years)**

7/1/14-10/31/14: develop test protocols; construct the lab-scale hydrogen and methane reactors  
 11/1/14-12/31/15: conduct lab-scale experiments to determine the optimal conditions for hydrogen and methane producing reactors and chemical scrubbers for pig manure co-fermented with sugar beet processing wastewater; and reporting

1/1/16-6/30/17: conduct lab-scale tests for the struvite reactor; develop test protocols for pilot-scale experiments; construct, install, and evaluate the on-site pilot scale system; analyze data; and reporting

**C. Long-Term Strategy and Future Funding Needs**

The long-term strategy is to promote the implementation of this technology among sugar beet and pig producers to protect the environment and conserve natural resources by generating renewable energy and a crop fertilizer. This will lead to 1) the long term win-win situation for the pig and sugar beet industries; 2) production of bioenergy and fertilizer from renewable resources to move Minnesota into a leading position in the nation in environmentally friendly agriculture; and 3) new information about the “waste-to-product” concept for a broad audience so that the goal of achieving a “green economy” in Minnesota will be embraced by all Minnesotans.

## 2014 Detailed Project Budget

**Project Title:** Clean water/renewable energy from beet waste/manure

### INSTRUCTIONS AND TEMPLATE (1 PAGE LIMIT)

*Attach budget, in MS-EXCEL format, to your "2014 LCCMR Proposal Submission Form".*

*(1-page limit, single-sided, 10 pt. font minimum. Retain bold text and DELETE all instructions typed in italics. ADD OR DELETE ROWS AS NECESSARY. If a category is not applicable write "N/A", leave it blank, or delete the row.)*

#### IV. TOTAL ENRTF REQUEST BUDGET 3 years

<b>BUDGET ITEM</b> <i>(See "Guidance on Allowable Expenses", p. 13)</i>	<b>AMOUNT</b>
<b>Personnel:</b> One 100% postdoc associate: salary: \$129,818; fringe: \$26,937 for three years; The postdoctoral associate will be responsible for the research in all aspects including developing test protocols, conducting experiments, collecting and analyzing samples and data, and preparing materials for publications and information dissemination. One 50%-time graduate student; salary: \$70,013; fringe: \$52,817 for three years; The graduate student will help the postdoc in preparing experiments; setting up experimental apparatuses; conducting experiments; and collecting data	\$ 279,585
<b>Contracts:</b> <i>In this column, list out proposed contracts. Be clear about whom the contract is to be made with and what services will be provided. If a specific contractor is not yet determined, specify the type of contractor sought. List out by contract types/categories - one row per type/category.</i>	\$ -
<b>Equipment/Tools/Supplies:</b> \$60,000 - supplies for constructing all the reactors including hydrogen fermenter, UASB, struvite reactor at both lab-scale and pilot-scale with all the control systems including reactor bodies, pumps, mixers, temperature and pH controllers, etc.; \$55,000 - sample analysis costs for over 1000 samples at \$55 each.	\$ 115,000
<b>Acquisition (Fee Title or Permanent Easements):</b> <i>In this column, indicate proposed number of acres and name of organization or entity who will hold title.</i>	\$ -
<b>Travel:</b> \$9,100 - in-state travel from Waseca to Moorhead area to collect samples and run experiments for two people including meals and lodging during the three year period (estimated \$700/trip x 13 trips).	\$ 9,100
<b>Additional Budget Items:</b> <i>In this column, list any additional budget items that do not fit above categories. List by item(s) or item type(s) and explain how number was reached. One row per type/category.</i>	\$ -
<b>TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST =</b>	<b>\$ 403,685</b>

#### V. OTHER FUNDS

<b>SOURCE OF FUNDS</b>	<b>AMOUNT</b>	<b>Status</b>
<b>Other Non-State \$ Being Applied to Project During Project Period:</b> <i>Indicate any additional non-state cash dollars to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.</i>	\$ -	<i>Indicate: Secured or Pending</i>
<b>Other State \$ Being Applied to Project During Project Period:</b> <i>Indicate any additional state cash dollars (e.g. bonding, other grants) to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.</i>	\$ -	<i>Indicate: Secured or Pending</i>
<b>In-kind Services During Project Period:</b> <i>Indicate any in-kind services to be provided during the funding period. For each type of service, list type of service(s), estimated value, and indicate whether it is secured or pending. In-kind services listed must be specific to the project.</i>	\$ 10,000	<i>secured; 10% of Dr. Jun Zhu's time</i>
<b>Remaining \$ from Current ENRTF Appropriation (if applicable):</b> <i>Specify dollar amount and year of appropriation from any current ENRTF appropriation for any directly related project of the project manager or organization that remains unspent or not yet legally obligated at the time of proposal submission. Be as specific as possible. Describe the status of funds in the right-most column.</i>	\$ -	<i>Indicate: Unspent? Not Legally Obligated? Other?</i>
<b>Funding History:</b> <i>Indicate funding secured prior to July 1, 2014, for activities directly relevant to this specific funding request, including past ENRTF funds. State specific source(s) of funds.</i>	\$ -	

Minnesota hog production distribution map

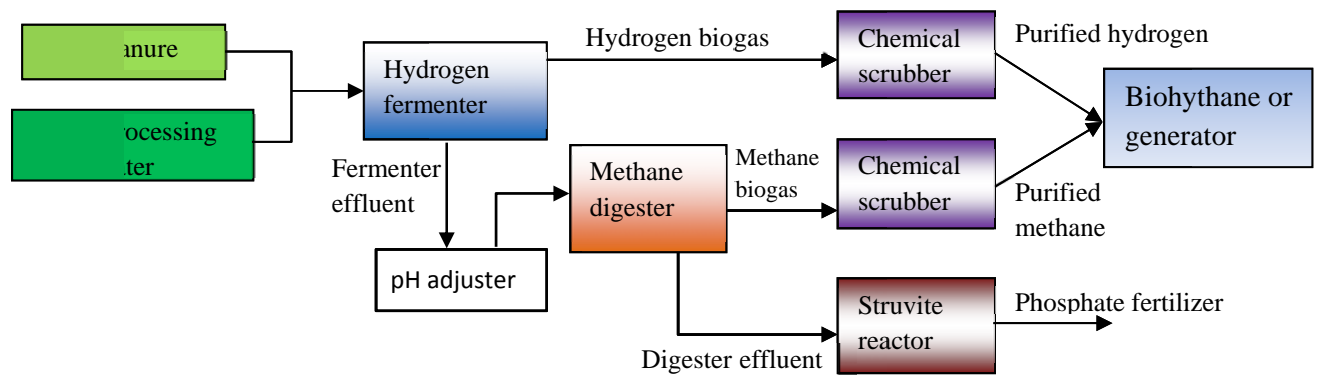
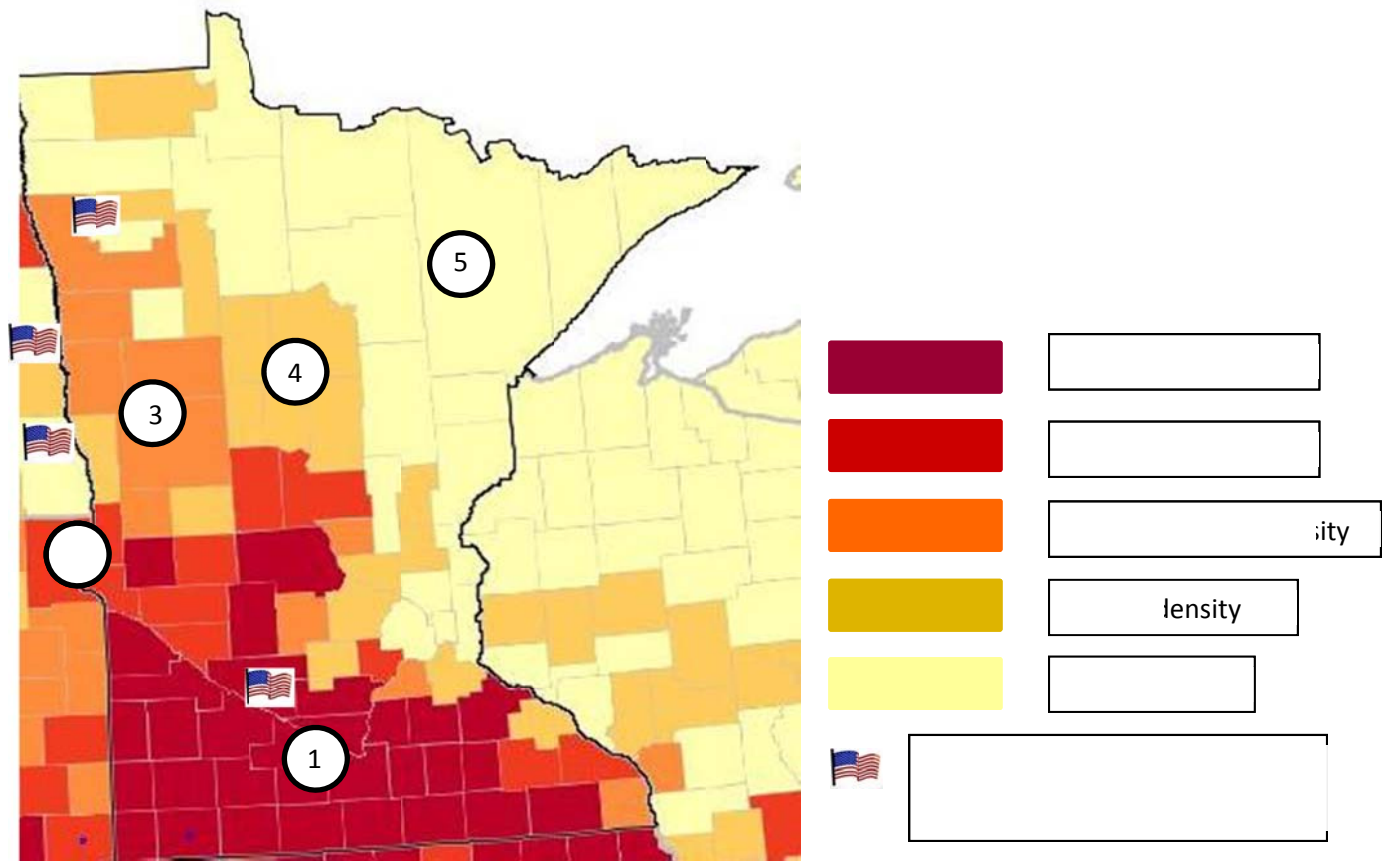


Figure 1. The schematic of the flowchart of the proposed treatment system

**Project manager:** Jun Zhu, Ph.D., Professor, Department of Bioproducts and Biosystems Engineering/Southern Research and Outreach Center, the University of Minnesota. Dr. Zhu has many years of experience in conducting research in using agricultural wastes as substrates to produce bioenergy and other value-added products. In the last 5 years, he has published over 50 papers in refereed journals in the subject area and made numerous presentations and talks across the nation and around the world. He is an internationally renowned expert in renewable energy research. Dr. Zhu will be mainly responsible for developing and evaluating each unit in the proposed treatment system, as well as the complete system in terms of bioenergy production and nutrients removal. He will be in charge of all the experiments to be conducted at the Southern Research and Outreach Center at Waseca, Minnesota. Dr. Zhu will also be responsible for reporting of the project outcomes to LCCMR.

**Organization:** The University of Minnesota is the flagship in higher education in Minnesota and is an 1862 land grant institution in the US. The University of Minnesota, founded in the belief that all people are enriched by understanding, is dedicated to the advancement of learning and the search for truth; to the sharing of this knowledge through education for a diverse community; and to the application of this knowledge to benefit the people of the state, the nation, and the world.