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

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Project Title:

Life Cycle Energy of Renewably Produced Nitrogen Fertilizers

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

Total Project Budget: $ 512,732

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

Other Non-State Funds: $ 0

Summary:

Fossil energy savings and greenhouse gas reductions of using local renewable energy technologies for fertilizer production are calculated using Life cycle assessment. Technological and economic feasibility are also examined.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

MP: 0613-2-072-proposa
Budget: 0613-2-072-bud
Qual: 0613-2-072-qualifi
Map: 0613-2-072-map-T
Resolution:
List:

_____ Funding Priorities _____ Multiple Benefits _____ Outcomes _____ Knowledge Base

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

Capacity Readiness Leverage Employment TOTAL

PROJECT TITLE: Life Cycle Energy of Renewably Produced Nitrogen Fertilizers

I. PROJECT STATEMENT

The Minnesota landscape supports over 14 million acres of cropland in grain production. Almost 600,000 tons of nitrogen fertilizers are needed annually to maintain productivity on this land. Most nitrogen fertilizers are manufactured using fossil energy and nitrogen from the air. In energy terms, production of Minnesota's nitrogen fertilizer requires the equivalent of 3,000,000 barrels of oil annually and costs farmers over $400 million. This is a significant use of fossil fuels in the state and results in a considerable amount of greenhouse gas (GHG) emissions. In addition, the absence of fossil energy resources in the State means that these synthetic nitrogen fertilizers must be imported into Minnesota from the other states and overseas. Between the linkage to fossil energy, GHG emissions, and supply issues, Minnesota's reliance on synthetic nitrogen fertilizers could prove problematic in the long run. However, there are opportunities to explore new nitrogen sources that could be more environmentally and economically sustainable.

As an initial step towards developing a renewable nitrogen fertilizer for the state, a pilot plant at the University of Minnesota, West Central Research and Outreach Center (WCROC) uses wind turbine electricity to produce ammonia, the most commonly used nitrogen fertilizer. Initial life cycle assessment (LCA) has shown that the WCROC wind to ammonia system is capable of producing ammonia fertilizer with very low fossil energy inputs and resulting GHG emissions; however, intermittent production of wind power will limit ammonia production during calm periods. Minnesota already has a broad portfolio of other renewable technologies capable of generating the hydrogen rich precursors needed for ammonia production; among these are biomass gasification, anaerobic digestion, and hydropower (using electrolysis). This project brings together chemical engineering researchers, industry professionals and life cycle assessment specialists to examine the life cycle energy costs, financial costs, and overall suitability of producing nitrogen fertilizers using renewable energy sources other than wind. Wind and conventional fossil-based ammonia will serve as baseline comparisons. Modeling for renewable energy systems will use data from existing Minnesota biomass and biogas facilities. A hydroelectric production system will be modeled using a composite of the 33 hydro plants operating in Minnesota.

A key objective in developing this information is to *identify the viability of producing nitrogen fertilizers using different renewable energy technologies,* which could significantly reduce fossil energy consumption and GHG emissions from the large agricultural sector in the State. Another important objective is to *provide options for expanding local renewable energy use in Minnesota's industrial base*. This would help *promote economic development and spur job creation in rural areas* and would extend the economic benefits beyond the agricultural community. A final objective is to *further develop the knowledge base of Minnesota researchers to conduct LCAs and techno-economic feasibility analyses of renewable energy and nitrogen fertilizer production systems.* These objectives are part of WCROC's overall goal of *reducing fossil energy use in agriculture and enhancing rural communities.*

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: *LCA Modeling of Renewable Nitrogen Production* **Budget: $ 196,477**

LCA modeling for renewable energy systems will use data from facilities such as the biomass gasification system located at Chippewa Valley Ethanol Cooperative, in Benson, MN, a local anaerobic digestion system, and a representative Minnesota hydroelectric production system. The research will be based on standard ISO14040 life cycle assessment methodology and examining energy (both renewable and fossil) and GHG.

Outcome	Completion Date
1. Life Cycle Assessment of Ammonia Production Via Biomass Gasification	*9/2015*
2. Life Cycle Assessment of Ammonia Production Via Anaerobic Digestion	*4/2016*
3. Life Cycle Assessment of Ammonia Production Via Hydro-electric Power	*11/2016*

Activity 2: *Techno-economic Analysis of Renewable Nitrogen Fertilization* **Budget: $ 226,477**

The technological and financial feasibility of adding ammonia production capabilities onto existing Minnesota commercial scale renewable energy facilities will be studied. Process modeling will use the Aspen+ modeling tool to examine the production process chemistry, equipment needs, and facility costs. Logistical considerations such as biomass and manure processing and transport will be added to the models to make them more applicable to real-world situations.

Outcome	Completion Date
1. Techno-Economic Model of Ammonia Production Via Biomass Gasification	*9/2015*
2. Techno-Economic Model of Ammonia Production Via Anaerobic Digestion	*4/2016*
3. Techno-Economic Model of Ammonia Production Via Hydro-electric Power	*11/2016*

Activity 3: *Analysis of Impacts on Agriculture and Information Dissemination* **Budget: $ 89,777**

The results from activities 1 and 2 will be used to generate Minnesota specific energy and greenhouse gas statewide impact estimates. The data will also be used to estimate impacts on the lifecycle energy and emissions of Minnesota agriculture and agricultural products. Results will be disseminated to stakeholders via stakeholder meetings, web publication of study findings, hard copy distribution of information, and publication of scientific papers.

Outcome	Completion Date
1. Assessment of Fossil Energy Impacts on Agriculture	*5/2017*
2. Industry Report on Feasibility of Different Renewable Ammonia Production Systems	*5/2017*
3. Information Dissemination Via Stakeholder Meetings and Print and Web Publications	*6/2017*

III. PROJECT STRATEGY

A. Project Team/Partners

This project will bring together a variety of specialists to complete the different technical, economic, energy and agricultural aspects of this project. The University of Minnesota, WCROC will coordinate the research efforts and provide overall project management. WCROC's experience in combining renewable energy systems with ammonia production, along with our interactions with local industry and other stakeholders allows WCROC a unique opportunity to evaluate renewable nitrogen fertilizer production systems. Chippewa Valley Ethanol Cooperative will be assisting with modeling the biomass energy to ammonia production in a gasification system. They have a gasification platform capable of using local biomass to produce hydrogen rich gas needed for ammonia production. We also intend to partner with a regional anaerobic digestion system operator. The team researching technology in these facilities includes Dr. Christian Hulteberg and his research group from Lund University, Sweden. His specialty is chemical engineering and, specifically, methods of production of hydrogen-based chemicals, such as ammonia. His group also examines the economics of production systems. Dr. Serina Ahlgren and her group from the Swedish Agricultural University are experts in life cycle analysis of nitrogen fertilizer production systems. WCROC is also in the early part of the process of hiring a new faculty member in renewable energy with an emphasis in bioproducts, who would be offered the opportunity to be part of this project team when they are hired.

B. Timeline Requirements

The project is set for a 3 year timeline. This timeframe allows adequate opportunity for field data collection, creation of models, and peer review of the information by the members of the team and industry partners. Information dissemination would occur after the final data was collected and analyzed.

C. Long-Term Strategy and Future Funding Needs

This project is designed to examine the feasibility of renewable production of nitrogen fertilizers and then, transfer that information to the private sector. While we will be available to assist stakeholders in a better understanding of this technology, informed private investors will be the key to long-term adoption of renewable ammonia production.

2014 Detailed Project Budget

Project Title: ***Life Cycle Energy of Renewably Produced Nitrogen Fertilizers***

IV. TOTAL ENRTF REQUEST BUDGET *3* years

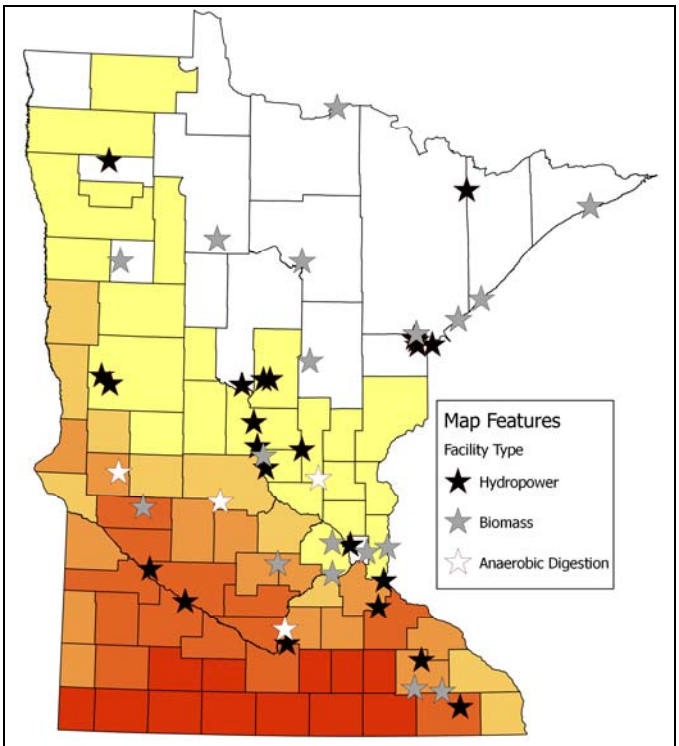
BUDGET ITEM *(See "Guidance on Allowable Expenses", p. 13)*	**AMOUNT**
Personnel: Project manager/Lead researcher (.75 FTE for 3 years) Junior scientist (.75 FTE for 3 years) student interns (Three per year for 3 years [14 week internships])	$ 334,732
Contracts: *Chemical engineering Researcher Team, Lund University Sweden. ($80,000) Responsible for analyzing the feedstocks, chemistry, and equipment, at the renewable energy sites in Minnesota. Will include the services of a faculty member and their grad student. Lifecycle assessment research team, Swedish agricultural University. ($50,000) Will assist University of Minnesota researchers with fertilizer specific pathways for analyzing lifecycle assessment. Will include the services of the lead faculty member and their graduate student. Stipend for Chippewa Valley ethanol Cooperative ($15,000) to compensate for staff time allocated for this project. CVEC work with with University of Minnesota research staff to identify inputs, outputs, and equipment needed for converting a commercial scale biomass gasification system into an ammonia production system. Will assist with review of final reports and stakeholder outreach information. Stipend for entity operating and anaerobic digestion system ($15,000). Entitiy would work with with University of Minnesota research staff to identify inputs, outputs, and equipment needed for converting a commercial scale biomass gasification system into an ammonia production system. Will assist with review of final reports and stakeholder outreach information.*	$ 160,000
Equipment/Tools/Supplies: General supplies for production of outreach materials, collection of data, and general project operations. Software updates to LCA software.	$ 9,000
Acquisition (Fee Title or Permanent Easements):	$ -
Travel: *In-State travel to research facilities being examined over the three-year period of the study. This will include vehicle mileage at standard government rate.*	$ 3,000
Additional Budget Items: Costs of printing outreach material and making CD copies available. Meeting expenses for hosting outreach meetings with stakholders.	$ 6,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 512,732

V. OTHER FUNDS

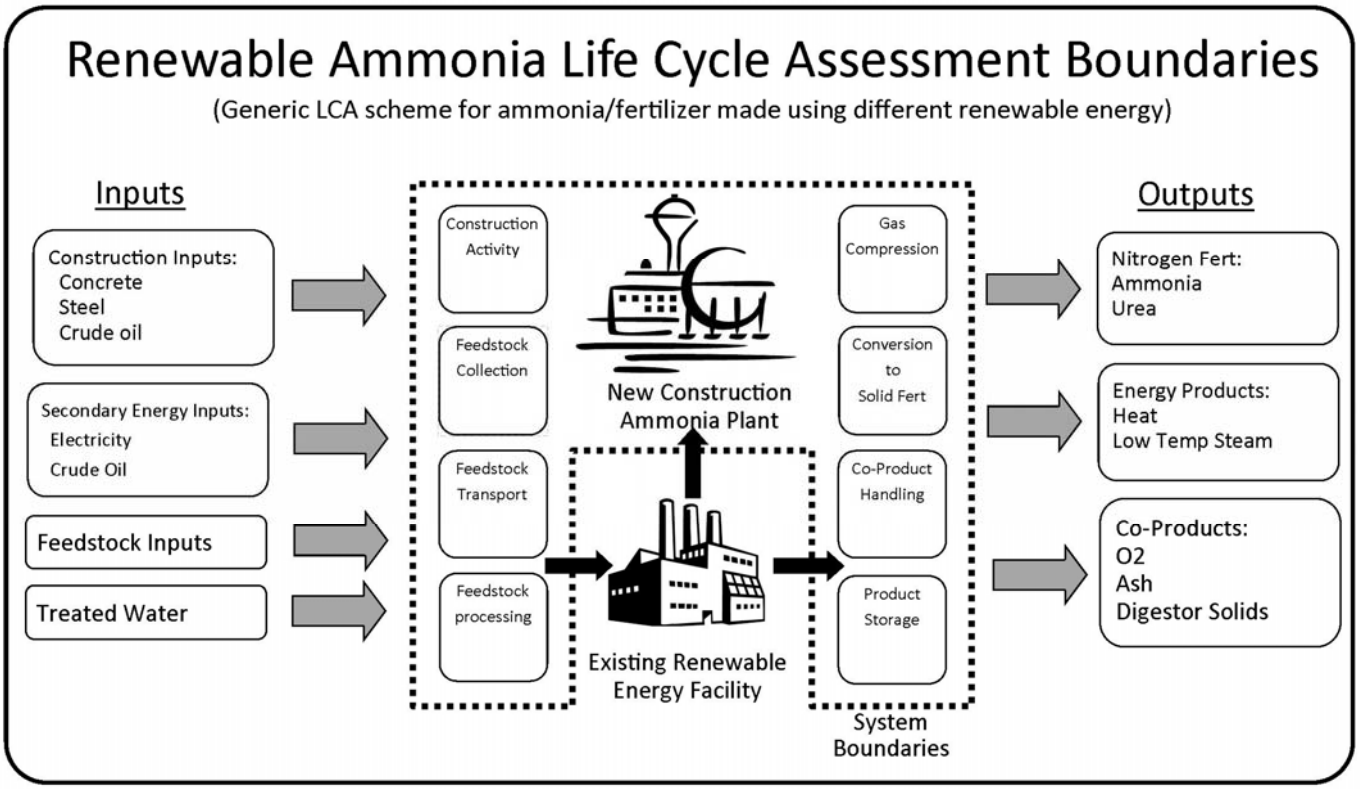
SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ Being Applied to Project During Project Period:	$ -	-
Other State $ Being Applied to Project During Project Period:	$ -	-
In-kind Services During Project Period: *The University of Minnesota is forgoing the typical 52% federally negotiated indirect cost recovery normally associated with research grants. This funding covers facilities, support staff, and other University activities that are not directly part of the research, but must be present to support research activities.*	$ 266,621	
Remaining $ from Current ENRTF Appropriation (if applicable):	$ -	-
Funding History: *This project is a extension of efforts to examine nitrogen fertilizer using wind power and the life-cycle fossil energy and emissions from that process. Several grants and state bonds have been awarded for the wind to system construction, including; $2.5 Million in bonding for the wind to ammonai facility from the state, LCCMR funding ($800,000), Several University allocations ($430,000), and funds from IREE ($88,000). Life-cycle assessment is being done with grants from a private entity ($100,000) and the Swedish Energy Agency ($120,000 total, $40,000 to WCROC).*	$4 million	

Environment and Natural Resources Trust Fund (ENRTF)
2014 Map and Project Graphic
Project Title: Life Cycle Energy of Renewably Produced Nitrogen Fertilizers

The **map (right)** illustrates the diversity of renewable energy facilities in Minnesota. It shows a selection of Minnesota based renewable energy facilities using biomass, hydropower, and anaerobic digestion to produce electricity, heat, and biomass, plus other co-products. This is overlaid against the areas of the state where there is a significant demand for nitrogen fertilizers. The **figure (below)** shows the major factors considered in a lifecycle assessment of renewably produced ammonia. The inputs included in the assessment would be items needed to build the ammonia production component of the system, secondary fossil energy inputs such as fuel, electricity, plus any treated water needed. The outputs would include the nitrogen fertilizer, any energy such as heat or steam, and co-products such as digester solids, ash, or purified oxygen. The type of renewable system would change some inputs and outputs, with biomass and anaerobic digestion facilities needing significantly more inputs, while hydro power would need less. These same inputs and outputs would be important for the economic assessment of the system, which would also include other logistical considerations depending on the renewable energy source.



Selected Renewable Energy Facilities in Minnesota and Corn Production Regions. Facilities indicated are a representative sampling of gasification, anaerobic digestion and hydropower systems. Darker areas indicated higher corn production, which typically requires more nitrogen.



Environment and Natural Resources Trust Fund (ENRTF)
2014 Project Manager Summary
Project Title: Life Cycle Energy of Renewably Produced Nitrogen Fertilizers

Project Manager:
Joel Tallaksen, Renewable Energy Scientist
West Central research and Outreach Center
University of Minnesota
Morris, MN 56267

Background: Joel Tallaksen has BS degrees in Genetics & Cell biology and Plant Biology, as well as a PhD from the University of Minnesota in Plant Biological Sciences. Following his thesis work, he worked in the private sector and applied his training to industry issues. His focus is on bringing together groups of industry, research, and stakeholder participants to examine applied problems in energy and environmental issues. In 2007, Joel began working as the Biomass Project Coordinator at the University of Minnesota, College of Food Agricultural and Natural Resource Sciences, West Central Research and Outreach Center. He coordinated the efforts of $1.8 million research project that developed an on-campus biomass gasification system which is capable of testing the potential of biomass energy and biomass feedstocks. His work covered many aspects of the project, including design of research equipment, development of our feedstock supply chain, organization of feedstock research, and outreach to the public via stakeholder meetings, website creation, and working with local and regional media. Joel leverage the knowledge and resources developed during the biomass gasification project to continue working with applied issues in biomass and other types of renewable energy. Projects included efforts to understand the willingness of agricultural producers to participate in biomass energy projects, lifecycle analysis of wind produced ammonia, and the lifecycle energy needs of agriculture.

Responsibilities for the proposed project: for this project, Dr. Tallaksen will be responsible for overall project management and supervision. He will track finances, reporting, and coordinate scheduling between project researchers. Joel and his team at WCROC will be in charge of collecting regionally appropriate information for energy and facility modeling. In collaboration with Dr. Serina Ahlgren, Joel will develop the initial lifecycle assessment models for the renewable ammonia systems being examined. He will assist Dr. Hulteberg as necessary in developing the techno-economic facility modeling. Following the modeling efforts, Joel will use the LCA data to assess how renewable fertilizers will impact the overall energy use in production agriculture. As completion of the research work begins to near, he will work with stakeholders, policymakers, and researchers to disseminate the information and provide informational and training opportunities for stakeholders.

Recent Grant Funded Activity: (Project title, funding agency, and funds awarded)

Integration of renewable and efficient energy technologies to green energy consumed in agricultural production systems- U of M IREE- $350,000

Sustainable nitrogen fertilizers based on renewable resources- Swedish Energy Agency- $40,000

Macrolevel Lifecycle Assessment Using Wind Energy For The Production Of Liquid Ammonia- Private Firm - $100,000.

Implications Of Corn Producer Participation Rates On Stover Biomass Markets- Minnesota Corn Growers/AURI/IREE- $40,000

West Central Regional Feedstock Partnership- USDA-SunGrant Regional Partnerships- $130,000.

Development And Validation Of Biomass Cropping Management Tools For Sustainable Harvesting Of Energy Production Feedstocks- Xcel Energy RDF- $970,000.

Organization Description: The University of Minnesota is a world class educational and research institution with campuses and research centers throughout the state. The combination of exceptional faculty and staff knowledge with the latest in research facilities and equipment gives the University of Minnesota the ability to consistently conduct ground-breaking research.