Environment and Natural Resources Trust Fund
2010 Request for Proposals (RFP)

LCCMR ID: 074-B3

Project Title:

Algae for Fuels Pilot Project

LCCMR 2010 Funding Priority:

B. Renewable Energy Related to Climate Change

Total Project Budget: $ $1,833,425

Proposed Project Time Period for the Funding Requested: 3 years, 2010 - 2013

Other Non-State Funds: $ $100,000

Summary:

Te demonstrate an innovative microalgae production system utilizing and treating wastewater. Algae are harvested and converted to biofules. Multiple ecological benefits including improving water quality, minimizing freshwater and land use.

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Sponsoring Organization: U of MN

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Location:

Region: Statewide

County Name: Statewide

City / Township: St. Paul

_____ Knowledge Base _____ Broad App. _____ Innovation

_____ Leverage _____ Outcomes

_____ Partnerships _____ Urgency _____ TOTAL

MAIN PROPOSAL

PROJECT TITLE: Algae for Fuels Pilot Project

I. PROJECT STATEMENT

Biomass energy is a viable alternative to fossil based energy supplies. However, significant advances in biomass energy technologies have encountered economic, ecological, and policy concerns, including feed stock procurement, energy balance, carbon footprint, competition for food and fuel, water use, etc. The University of Minnesota will partner with the Metropolitan Council Environment Services (MCES) to carry out an "Algae to Fuels" demonstration project which is expected to simultaneously address economic and environmental concerns. This project advances our existing collaborative R&D partnership, and will ***demonstrate an innovative photosynthetic algae production system*** which simultaneously produces high lipid oil for bio-diesel production, captures and recycles N and P from waste water, and sequester CO_2 from sludge incineration.

The **GOAL** of the project is to develop, build, and test a pilot scale (treating over 125 tons/day highly concentrated wastewater "centrate" and producing over 100 Kg /day dry algal biomass) algae production system at the MCES Metro waste water treatment facility. Algae will be grown, harvested, and converted into biofuels after extraction of higher-value components such as phosphorus and nitrogen. The project is expected to have ***multiple ecological benefits*** including improving water quality, minimizing freshwater and land use, reducing carbon emission, capture and recycling of plant nutrients, and producing clean, green energy.

The technology with further R&D efforts can potentially be implemented in wastewater treatment facilities, and adapted to other waste streams (livestock waste, food production wastes) in the long term. The knowledge gained will be documented and disseminated to the public and academic communities. The system will also be used for field demonstration and publicized through various educational outreach and communication activities.

II. DESCRIPTION OF PROJECT RESULTS

Result 1: *Pilot Scale System for Production of Algae on Wastewater* **Budget: $ 1,253,425**

Develop, design, and construct a pilot scale (1 dry ton algal biomass/day) algae production system utilizing proprietary continuous flow enclosed photobioreactors (PBR). Our design also utilizes CO_2 from burning of sludge and recovers P and N in the wastewater through algae. Therefore our design maximizes the green benefits of algae production. Specific activities include: (1) conduct preparatory research to determine and optimize process parameters for a large pilot scale algae production system, (2) design the pilot scale algae production and harvest system, (3) construct the system, and (4) test and improve the system and process parameters.

Deliverable	**Completion Date**
1. Optimized process parameters necessary for the design of a large pilot scale algae production system	*12/31/2010*
2. Production and harvest system development	*12/31/2011*
3. System construction and installation	*06/30/2012*
4. System testing and improvement	*12/31/2012*

Result 2: *Lab Scale Algae to Fuel Conversion Technology* **Budget: $ 380,000**

The planned activities include development and demonstration of technologies for converting algal biomass to bio-fuels including biodiesel. We will advance research on direct conversion processes which either extract lipids from wet algae or convert wet algae directly to fuels without the expensive drying process. In this project, we will (1) optimize direct conversion processes, (2) design and construct large lab scale systems, (3) develop P and N recovery process through algae processing, and (4) test and demonstrate the systems.

Deliverable	**Completion Date**
1. Optimized direct conversion processes	*06/30/2011*

2. Design and construction of the conversion systems	*06/30/2012*
3. Develop P and N recover process	*06/30/2013*
4. Evaluation data and demonstration	*06/30/2013*

Result 3: *Evaluation, Demonstration, and Outreach* **Budget: $ 200,000**

We will evaluate and demonstrate the systems and present our results to the general public, in scientific and trade journals, and to funding agencies. Specifically, we will (1) evaluate the systems against designed technical specifications; (2) evaluate and quantify the green impacts and benefits with respect to pollutant removal, water usage and quality, carbon sequestration, energy balance, and fuel quantity and quality, and conduct economic and environmental life-cycle analysis; (3) demonstrate the systems and processes to stakeholders; and (4) present the project data to funding agencies, academic community, and the general public through reports, seminars, meetings, and journal publications.

Deliverable	**Completion Date**
1. Technical evaluation data	*12/31/2012*
2. Environmental, ecological, and techno-economic evaluation, and life-cycle analysis data	*06/30/2013*
3. Demonstrations	*06/30/2013*
4. Project report and presentations	*06/30/2013*

III. PROJECT STRATEGY

A. Project Team/Partners

The project will be carried out by a team of researchers and engineers from UMN and MCES.

Dr. Roger Ruan, Professor, Director, Center for Biorefining, Department of Bioproducts and Biosystems Engineering (BBE), UMN, will be the PI & project director. He will be responsible for overall project planning and budget control, development, design and evaluation of enclosed photobioreactors, development and evaluation of processes and lab scale systems for conversion of algae to fuels. He will also lead demonstrations and present project results.

Dr. Robert Polta, Director of Research, Metropolitan Council Environmental Services (MCES), a registered professional engineer in Minnesota, will be a co-PI of the project. He will be responsible for demonstration site preparation and coordinate construction, installation and operation of the production system. He will also lead efforts in evaluating the environmental and ecological benefits of the project.

Dr. Paul Chen, Program Director, Center for Biorefining, Dept of BBE, UMN, will be a co-PI. He will be responsible for experiment design and coordination, monitoring and documentation of project progress and results, and publicizing the project. He will also be involved in development of conversion processes.

Dr. Dean Current, Program Director, Center for Integrated Natural Resources and Agricultural Management, UMN, will be a co-PI and will be responsible for conducting the economic and environmental life-cycle analysis.

B. Timeline Requirements

This is a three-year project. The first two years are required to develop and construct the systems. In the third year, the systems will be tested and demonstrated. Additional data will be collected during testing and demonstration, which will be of importance to further R & D and eventual technology transfer. An educational outreach and communication strategy will be conducted throughout the project

C. Long-Term Strategy

The proposed project, built on our existing R & D efforts, does not need additional investment other than the requested financial support to complete. However, further R & D leading to eventual technology transfer and commercialization will be our long-term goal and will require additional funding. Next level scale-up pilot facilities must be demonstrated with federal, state, and private funding before the technology can be commercialized.

Project Budget

IV. TOTAL PROJECT REQUEST BUDGET (3 years)

BUDGET ITEM	AMOUNT
Personnel:	$ -
Paul Chen, co-PI, 30%, 3yrs, including 32.3% benefits, project coordination, conducting R&D, project evaluation, progress report	$ 86,728
Dean Current, co-PI, 15%, 3yrs, including 32.3% benefits, conducting R&D, economic and environmental life-cycle analysis	$ 43,364
2 Postdocs, 100%, 3yrs, including 19.75% benefits, conducting R&D, operations, demonstration, data analysis	$ 299,053
2 Graduate Research Assistants, 50%, 3yrs, including 16.84% benefits and tuitions, conducting R&D, operationg, demonstration	$ 180,712
Equipment/Tools/Supplies:	$ -
Pilot scale algae production and harvest system and auxiliary equipment for demonstration	$ 400,000
Algal biomass conversion equipment	$ 80,000
Lab and operation supplies: materials for making lab scale reactors for testing, nutrients, cultures, chemicals for analysis, lab supplies, consumables for analytical instruments, external analysis services	$ 381,500
Travel:	$ -
In-state travel: meals and usage of University and personal vehicles for researchers travel between campus and demonstration site	$ 10,000
Additional Budget Items:	$ -
Operation services: including labors (hourly worker at Metro Plant hired by MCES, $150,000), analysis for monitoring ($40,000), supplies, maintenance and repair, including pumps, hoses, valves, control components, lights, tanks, mixers, polymers, etc., and their repair and replacement services ($99,636), all for operating the pilot and demonstration systems at the Metro Plant.	$ 289,636
Consulting services: fees for external consultant to assist in oil extraction process development (first two years)	$ 62,432
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 1,833,425

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period: gift funds will be used for algal biomass conversion research	$ 100,000	*secured*
Other State $ Being Applied to Project During Project Period:	$ -	*N/A*
In-kind Services During Project Period: spaces and utility donated by MCES and co-PI Dr. Bob Polta's 20% time.		secured
Remaining $ from Current Trust Fund Appropriation (if applicable):		*N/A*
Funding History:	$ -	
Xcel Energy (2007-2008): Development of mass algae culture systems	$ 150,000	secured
MCES (2006-2009): Mass Culture of Algae as an Energy Crop for Biofuel Production by Utilizing Wastewater and Flue Gas from Wastewater Plant	$ 540,000	secured
MCES (7/1/2009-6/30/2010): Mass Culture of Algae as an Energy Crop for Biofuel Production by Utilizing Wastewater and Flue Gas from Wastewater Plant	$ 125,000	pending
IREE (2006-6/30/2010): Mass Culture of Algae as an Energy Crop for Biofuel Production by Utilizing Wastewater and Flue Gas from Wastewater Plant	$ 540,000	secured
Other related privite gift supports	$ 100,000	secured

Project Manager Qualifications and Organization Description

Dr. Roger Ruan, Professor and Director, Center for Biorefining and Department of Bioproducts and Biosystems Engineering, co-leader of Bioenegy and Bioproducts Cluster of the Initiative of Renewable Energy and Environment (IREE), University of Minnesota, is the project manager of the proposed project. Dr. Ruan's research focuses on renewable energy and the environment as well as food safety and quality. Dr. Ruan has published over 200 papers in refereed journals, books, and book chapters, and over 300 additional meeting papers and other reports, and holds 12 US patents. He has supervised more than 40 graduate students, 60 post-doctors, research fellows, and other engineers and scientists, and 7 of his students hold university faculty positions. He has received over 100 projects totaling over $17 millions in various funding for research. He is an editor-in-chief of the *International Journal of Agricultural and Biological Engineering* and editorial board member of *Journal of Food Process Engineering*, and Associate Editor of *Transactions of ASABE*, *Engineering Applications in Agriculture, and Transactions of CSAE*. Dr. Ruan has given over 140 invited symposium presentations, company seminars, and short courses, and has been a consultant for many local, national, and international companies and agencies in renewable energy and products as well as food and value-added processing areas. Dr. Ruan has also given frequent interviews on related topics to various news media.

Dr. Ruan has very active ongoing research programs on renewable energy. Algae production and processing is a major focus of his current research. They have screened more than 100 microalgae species and strains collected from commercial algae banks and local waters. Several species and strains have been identified as candidates for mass culture on concentrated wastewater. They have developed and tested many algae culture systems. One system with great potential for cost effective production of algae is being closely evaluated and a patent disclosure has been filed. Two small pilot systems have been built and are being tested in a green house on St. Paul campus and in one of the MCES wastewater plants in St. Paul. Both of the Center for Biorefining and MCES have the expertise and experience to develop, construct, and operate pilot scale microalgae production systems.

The Center for Biorefining is affiliated with the University of Minnesota Initiative for Renewable Energy and the Environment to coordinate the University efforts and resources to conduct exploratory fundamental and applied research; 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 arts analytical instruments, and processing facilities ranging from bench to pilot scale.