

**2005 Project Abstract**

For the Period Ending June 30, 2007

**TITLE:** Biomass-Derived Oils for Generating Electricity and Reducing Emissions

**PROJECT MANAGER:** Darrick Zarling  
**ORGANIZATION:** University of Minnesota  
**ADDRESS:** 1100 Mechanical Engineering  
111 Church St. SE  
Minneapolis, MN 55455-0111  
612-624-3504  
**WEB SITE ADDRESS:** [www.me.umn.edu/centers/cdr/](http://www.me.umn.edu/centers/cdr/)

**FUND:** Trust Fund

**LEGAL CITATION:**

For 2005 the exact language is: ML 2005, First Special Session, Chp. 1, Art. 2, Sec. 11, Subd. 10(g).

**APPROPRIATION AMOUNT:** \$ 150,000

Overall Project Outcome and Results

This project is one portion of a larger program to identify and test Bio Derived Oils (BDOs) based fuels for use in a commercial power-generating turbine. This project assisted with an effort to pilot the use of BDOs on a smaller scale in a micro turbine in order to evaluate and demonstrate the potential application of BDOs in the operation of large scale electricity generating turbines. The funds allowed for the purchase of a micro turbine generator. The micro turbine was installed and calibrated and tests are being conducted as part of the larger program to understand the effects of using BDOs on turbine emissions and performance. Those tests are being funded by the Minnesota Soybean Research and Promotion Council (MSR&PC) and are scheduled to be completed by December 2008.

Project Results Use and Dissemination During the project, data and information was shared with the AURI, MSR&PC and the University of Minnesota. Updates were published in AURI's Ag Innovation News. Information was included on the University of Minnesota's Center for Diesel Research web site and other appropriate web sites.

## LCMR Preliminary Final Work Program Report

**Date of Report:** Aug 28, 2007  
**Project Completion Date:** Dec 31, 2008 Final Report

**I. PROJECT TITLE:** Biomass-Derived Oils for Generating Electricity and Reducing Emissions

**Project Manager:** Darrick Zarling  
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**Location:** University of Minnesota

<b>Total Biennial LCMR Project Budget:</b>	<b>LCMR Appropriation:</b>	<b>\$ 150,000</b>
	<b>Minus Amount Spent:</b>	<b>\$ 121,093</b>
	<b>Equal Balance:</b>	<b>\$ 28,907</b>

**See Attachment A for Budget Detail.**

**Legal Citation:** ML 2005 1<sup>st</sup> Special Session, Chap. 1, Article 2, Sec. 11 Subd. 10g

**Appropriation Language:** \$75,000 the first year and \$75,000 the second year are from the trust fund to the University of Minnesota to evaluate the environmental and performance benefits of using renewable biomass-derived oils, such as soybean oil, for generating electricity

**Update:** A late start on the project due to delays in related work prevented the completion of the entire project in the original timeframe which limited the amount of labor expenditures incurred by the project. The project will be completed with additional funds other sponsors.

### **II. and III. FINAL PROJECT SUMMARY:**

In order to demonstrate the applicability of biomass-derived oils in the operation of large scale electricity generating turbines, it is prudent to demonstrate the use of these fuels on a smaller scale, in a small turbine as a proof of the concept. Therefore, a new micro turbine generator was purchased to allow for the evaluation of Bio Derived Oils (BDOs) in a small turbine. The effect of running a BDO based fuel on turbine emissions and performance will be determined. The

micro turbine, fuel tanks heaters and controls were installed in a 20 foot trailer by Unison Solutions of Dubuque Iowa. The fuel system includes a 500 gallon tank for the BDO and a 5 gallon tank for diesel fuel. The diesel fuel will be used to start the turbine if needed and to flush the system at the end of the operating period. Manual valves were installed to allow the user to switch between fuels and an inline heater is included that is capable of heating the BDO to 250 °F. The build progress on the system was monitored and a final inspection was conducted at the Unison facility in Dubuque. The trailer was delivered to the University of Minnesota where it is currently stored at the UMore Park facility in Rosemount, MN.

A portable emissions analyzer was specified and procured. The analyzer performance and calibrated has been verified.

Concurrent to this project, progress has been made on a related project to develop a turbine BDO based fuel and conduct laboratory tests on that fuel. That work is scheduled for completion in December, 2007.

Preparations for the durability test on the micro turbine have been initiated. The test will most likely occur on the University's St Paul campus with some preliminary testing of the micro turbine in the Mechanical Engineering building on the Minneapolis Campus. Matching funds have been acquired from the Minnesota Soybean Research and Promotion Council (MSR&PC) and the Agricultural Utilization Research Institute (AURI). The completion of the durability study of scheduled for December, 2008.

#### **IV. OUTLINE OF PROJECT RESULTS:**

This project is a portion of a larger program to identify and test BDO based fuels for use in a commercial power-generating turbine. The initial components of the program have been funded by Xcel Energy and the Minnesota Soy Growers and are underway. Candidate fuels have been selected and have been analyzed. This has led to the selection of Refined Bleached Deodorized soybean oil and Biodiesel as the fuels to be further evaluated under this program. It has been determined that preheating will be required for soybean-based oils to reduce their viscosity prior to injection into the turbine combustion chamber. Waste heat from the turbine can be used for preheating the fuel although electric heating will be used for this project. These fuels and their blends have been evaluated for their atomization and combustion properties and will soon be run in a lab scale turbine. An economic study on the use of these lower cost fuels for the generation of electricity has also been completed.

The completion of this project will provide the necessary performance data that is required before evaluating the biofuels in a larger, axial flow turbine of about 1000 – 2000 kilowatts. Upon completion of that evaluation, the goal is to demonstrate the use of a biofuel in a commercial power-generating turbine (25,000 – 200,000 kilowatts).

## *Durability Testing on a 30 kW Micro Turbine*

**Result 1:** Field site selection and microturbine installation.

**Description:** Based on the results of testing currently being conducted at the University of MN, a biomass-derived fuel will be selected for evaluation in the microturbine. Micro turbine suppliers will be contacted, and a 30 kW micro turbine will be selected, purchased, and installed in a portable facility with associated fuel tank and electrical support equipment.

<b>Summary Budget Information for Result 1:</b>	<b>LCMR Budget:</b>	<b>\$126,885</b>
	<b>Minus Amount Spent:</b>	<b>\$121,093</b>
	<b>Equal Balance:</b>	<b>\$ 5,792</b>

**Update:** A 30 kW Capstone micro turbine has been purchased and installed in a portable facility with associated fuel tanks and electrical support equipment.

**Completion Date:** June 30, 2007

**Result 2:** Durability and emissions testing of biofuel on microturbine.

**Description:** The necessary electrical hookups will be made to either supply the electricity produced to the facility or to the grid. Make all necessary preparations for conducting emissions tests and durability testing. Baseline emissions tests will be conducted using diesel fuel. The gaseous emissions of carbon monoxide, nitrogen oxides, and hydrocarbons will be measured, as well as particulate emissions. After completing the tests using diesel fuel, the microturbine will be switched over to the biomass-derived fuel, and the emissions tests will be repeated. A durability test of up to 2000-hours using the biofuel will be conducted, and the performance and emissions of the microturbine monitored during the test. At the completion of the test, the turbine manufacturer will inspect the turbine for deposits within the turbine, or any unusual wear that may result using the selected fuel. A final report will be prepared summarizing the project, and will include data from the emissions and durability testing. The durability test will proceed to 2000 hours unless there is a system failure preventing the operation of the turbine.

<b>Summary Budget Information for Result 2:</b>	<b>LCMR Budget</b>	<b>\$ 0</b>
	<b>MSRPC</b>	<b>\$50,000</b>

**Update:** March 13, 2007: The funding available during the period of July through December, 2007 will be used for final site selection and to begin the installation/hookup of the gen-set.

The durability testing will begin upon completion of Xcel RDF funded project, which will conclude with the testing of the candidate BDO based fuels in a lab scale turbine. Additional funding has been acquired to complete the durability testing. The Xcel RDF funded project is expected to be completed in Dec of 2007. During

the course of that project, a final selection of the bio fuel to be used will be made. Final preparations for the durability testing will be made from January through April, 2008. The durability testing will take 4 to 6 months. The data analysis and final report preparation will be conducted during the 4th quarter of 2008.

The funds from the Minnesota Soybean Research and Promotion Council will be split between 2007 and 2008, with \$10,000 available during 2007 and \$40,000 available during 2008. A letter of commitment of these funds was provided separately. In addition to the supporting the labor to do that above tasks, the MSRPC funds will provide \$3,500 to contract for micro turbine manufacturer to travel to the test site, and examine micro turbine for wear or deposit formation at the conclusion of the test.

**Completion Date: Dec 2008**

**Final Report Summary:**

**V. TOTAL LCMR PROJECT BUDGET:**

**All Results: Personnel: \$11,017**

**All Results: Equipment: \$97,368** (purchase of micro turbine and install in a portable facility with fuel tank and associated electrical equipment)

**All Results: Development: \$**

**All Results: Acquisition: \$**

**All Results: Other: \$ 2,000** (contract for installation/electrical hookup of microturbine)

**\$13,500 Purchase of emission measurement equipment**

**\$ 1,000 Travel for inspection of microturbine acceptance test**

**\$ 2,000 Startup and Commissioning**

**TOTAL LCMR PROJECT BUDGET: \$126,885**

**Explanation of Capital Expenditures Greater Than \$3,500:**

- 1) \$97,368 required for the purchase of a 30 kW microturbine and delivery to the test site.
- 2) \$13,500 Purchase of emission measurement equipment Rental fees would exceed half the capitol cost

Note: At the end of this project we will discuss with LCMR staff the final disposition of the microturbine. At this time, there are three options:

- 1) Leave microturbine in place: Continue demonstration with the biofuel, and the University could continue monitoring performance pending the receipt of funds.
- 2) Donate microturbine to the University of Minnesota: The microturbine could be used at the University for research and teaching purposes.
- 3) Sell the microturbine and return the proceeds from the sale to the LCMR.

**VI. OTHER FUNDS & PARTNERS:**

**A. Project Partners:** The Anamax Group, the Minnesota Soybean Processors, or Archer Daniels Midland may provide fuel. The Agricultural Utilization Research Institute (AURI) will provide technical support during the course of the study. None of the cooperators will receive monies from the appropriation.

**B. Other Funds being spent during the Project Period: MSGA will provide \$50,000 for the completion of Result 2** AURI will provide technical support, with an estimated value of \$5,000.

**C. Required Match (if applicable):** none

**D. Past Spending:** Over the last two years, the University of MN and AURI has received about \$460,000 in funding to evaluate biomass-derived oils as turbine fuels.

**VII. DISSEMINATION:** During the project, data and information will be shared with the Agricultural Utilization Research Institute, the University of Minnesota, and the cooperator providing the test site. Updates will be published in AURI's Ag Innovation News. Information will be included on the University of Minnesota's Center for Diesel research web site and other appropriate web sites to be identified as the project progresses.

**VIII. REPORTING REQUIREMENTS:** A final work program report and associated products will be submitted by Dec 2008.

Attachment A: Budget Detail for 2005 Projects

Proposal Title: Biomass-Derived Oils for Generating Electricity and Reducing Emissions (# E-06)

Project Manager Name: Darrick Zarling

LCMR Requested Dollars: \$126,885 - MSRPC Requested Dollars: \$50,000

- 1) See list of non-eligible expenses, do not include any of these items in your budget sheet
- 2) Remove any budget item lines not applicable

2005 LCMR Proposal Budget	Result 1 Budget:	Amount Spent (date)	Balance (date)	Result 2 Budget:	Amount Spent (date)	Balance (date)	
	<i>Field site selection and microturbine installation</i>			<i>Durability and emissions testing of biofuel on microturbine</i>			
<b>BUDGET ITEM</b>	Trust Fund/LCMR			Other Funds			<b>TOTAL FOR BUDGET</b>
<b>PERSONNEL: Staff Expenses, wages, salaries –</b> <i>Be specific on who is paid \$, to do what? Make each person paid a separate line item</i>							
Robert Waytulonis	1,055			1,200			2,255
Kelly Strebig	1,103			5,320			6,423
Darrick Zarling	4,680			19,200			23,880
John Gage	1,280			7,422			8,702
Total	8,118	8,561	-443	33,142			41,260
<b>PERSONNEL: Staff benefits –</b> <i>Be specific; list benefits for each person on a separate line item</i>	11,017	11,343	-326				
Robert Waytulonis (fringe rate 0.336% of salary)	349			397			746
Kelly Strebig (fringe rate 0.344% of salary)	398			1,921			2,319
Darrick Zarling (fringe rate 0.344% of salary)	1,689			6,931			8,621
John Gage (fringe rate 0.344% of salary)	462			2,679			3,141
Total	2,899	2,782	117	11,928			14,827
<b>Contracts</b>							
<b>Professional/technical</b> (Capstone Microturbine for microturbine checkout at end of field demo)				3,500			3,500
<b>Other contracts</b> (Installation/electrical hookup at field site)	2,000	0	2,000				2,000
<b>Other direct operating costs</b>							0
<b>Equipment / Tools</b> (portable emissions monitoring equipment)	13,500	11,954	1,546				
30 kW microturbine installed in trailer	97,368	97,368	0				97,368
<b>Other Supplies</b> (list specific categories)							
Plumbing/materials - startup and commissioning	2,000	0	2,000				2,000
Rental of gas instrumentation							0
Emissions measurement supplies				930			930
Total	2,000	0	2,000	930			2,930
<b>Travel expenses in Minnesota</b>	1,000	427	573	500			1,500
<b>COLUMN TOTAL</b>	126,885	121,093	5,792	50,000			163,385