

2005 Project Abstract

PROJECT TITLE: *Natural gas production from agricultural biomass*

Project Manager: David Nichols Affiliation: Sebesta Blomberg

Technical Support: Cecil Massie

Mailing Address: 2381 Rosegate

City / State / Zip : Roseville, MN 55113

Telephone Number: 651-634-7242

E-mail Address: dnichols@sebesta.com

cmassie@sebesta.com

FAX Number: 651-634-7400

Web Page address: www.sebesta.com

FUND: LCMR 2005

Total Biennial LCMR Project Budget:

Legal Citation: ML 2005, [Chap.1st Special SS, Chapter 1, Article 2 Sec11, Subd.10(f).

Appropriation Language:

10 (f) Natural Gas Production from Agricultural Biomass

\$50,000 the first year and \$50,000 the second year are from the trust fund to the commissioner of natural resources for an agreement with Sebesta Blomberg and Associates to demonstrate potential natural gas yield using anaerobic digestion of blends of chopped grasses or crop residue with hog manure and determine optimum operating conditions for conversion to natural gas.

LCMR Appropriation: \$ 100,000

BALANCE \$ 5,214.34

Overall Project Outcomes and Results:

The overall objective of this project was to develop a roadmap for the production of pipeline quality natural gas from mixtures of hog manure and biomass. If this process is economic, then hog farmers will have an economic incentive to treat their wastes in a manner that eliminates odor and reduces the environmental footprint of hog operations.

This project was comprised of two primary elements: an experimental program to determine if crop residues could be combined with hog manure to increase biogas production and an engineering study to develop regional biogas production as a means to make treating hog manure economically attractive.

The study considered beet pulp, corn stalks or stover, wheat straw and switchgrass. The experimental study began with the assumption that these biomass sources could be digested in an anaerobic digester based on published literature values for gas generation. In the experiments, only the corn stover showed any gas generation but the gas generated would not be enough to be economic. The conclusion is that some form of pretreatment will be necessary before the biomass is fed to the digester. Acid hydrolysis as developed by the Department of Energy for biomass to ethanol or fungal composting are two candidate pretreatment technologies that could make biomass digestion economic. However, it is known from prior work that wood wastes such as sawdust will generate gas without pretreatment. This limits pretreatment to those technologies that are simple and inexpensive.

The second portion of the project was an engineering study of what regional biogas production would look like. This concept assumes multiple digesters located at individual hog (or dairy) operations producing biogas.

With the addition of substrate, gas production is expected to increase sharply. Consolidating biogas from multiple locations into a single refinery is more capital efficient than dispersed refining units and allows for a single connection to the natural gas pipeline. The engineering feasibility study showed that very large hog operations are candidates for biogas production but smaller farms, under 5000 hogs, were not. There is a substantial economy of scale in gas refining and consolidation of multiple farm output is more likely to be successful.

The overall economics of biomass/hog manure digestion are potentially attractive if long term gas purchase agreements and long term financing can be assembled. The primary result of this effort has been to assemble a roadmap for regional biogas production. Minnesota will benefit from this project as the economic analysis and engineering details facilitate follow on project development in specific locations. The successful implementation of this strategy will dramatically reduce the environmental damage from stored manure odors and pollution. In addition to the broadly shared benefits of reducing hog odors, specific property owners down wind of hog operations could see property values go up and an enhanced quality of life.

The project ended with a net balance because the final step of engineering a final system based on biomass could not be completed. When the biomass/hog manure mixture did not produce gas, there was no data to size the digesters or the biomethane refinery.

A full report, compiling the engineering study and experimental results was submitted.

LCMR 2005 Work Program

Date of Report: August 2007

LCMR Final Work Program Report

Date of Next Status Report: This is the final work program report

Date of Work program Approval:

Project Completion Date: June 2007

I. PROJECT TITLE *Natural gas production from agricultural biomass*

Project Manager: David Nichols **Affiliation:** Sebesta Blomberg

Technical Support: Cecil Massie

Mailing Address: 2381 Rosegate

City / State / Zip : Roseville, MN 55113

Telephone Number: 651-634-7242

E-mail Address: dnichols@sebesta.com

cmassie@sebesta.com

FAX Number: 651-634-7400

Web Page address: www.sebesta.com

Location: Roseville, MN 55113

| | | |
|--|----------------------------|--------------------|
| Total Biennial LCMR Project Budget: | LCMR Appropriation: | \$ 100,000 |
| | Minus Amount Spent: | \$94,785.66 |
| | Equal Balance: | \$ 5,214.34 |

Legal Citation: ML 2005, [Chap.1st Special SS, Chapter 1, Article 2 Sec11, Subd.10(f).

Appropriation Language:

10 (f) Natural Gas Production from Agricultural Biomass
\$50,000 the first year and \$50,000 the second year are from the trust fund to the commissioner of natural resources for an agreement with Sebesta Blomberg and Associates to demonstrate potential natural gas yield using anaerobic digestion of blends of chopped grasses or crop residue with hog manure and determine optimum operating conditions for conversion to natural gas.

II. and III. Final Project Summary

The overall objective of this project was to develop a roadmap for the production of pipeline quality natural gas from mixtures of hog manure and biomass. If this process is economic, then hog farmers will have an economic incentive to treat their wastes in a manner that eliminates odor and reduces the environmental footprint of hog operations.

This project was comprised of two primary elements; an experimental program to determine if crop residues could be combined with hog manure to increase biogas production and an engineering study to develop regional biogas production as a means to make treating hog manure economically attractive.

The study considered beet pulp, corn stalks or stover, wheat straw and switchgrass. The experimental study began with the assumption that these biomass sources could be digested in an anaerobic digester based on published literature values for gas generation.

In the experiments, only the corn stover showed any gas generation but the gas generated would not be enough to be economic. The conclusion is that some form of pretreatment will be necessary before the biomass is fed to the digester. Acid hydrolysis as developed by the Department of Energy for biomass to ethanol or fungal composting are two candidate pretreatment technologies that could make biomass digestion economic.

IV. OUTLINE OF PROJECT RESULTS:

The project was comprised of two major sections, an experimental phase and an engineering feasibility phase. It was anticipated that the results of the experimental phase would set the design conditions for the engineering study.

EXPERIMENTAL RESULTS

Tests were conducted on switchgrass, beet pulp and corn stover mixed with hog manure. Hog manure and the various substrates were digested separately as well.

In the end, none of the mixtures produced the volume of gas necessary to make the processes economic. Switchgrass and beet pulp were effectively inert in the digester while corn stover produced some gas of uncertain composition.

Knowing what we do now, we would have included some form of pretreatment into the experimental protocol such as dilute acid hydrolysis or a cooking step to weaken the cell walls and liberate the carbon for digestion.

The investment in equipment for testing biomass and other substrates continues to yield experimental results since the completion of this study. Multiple parties are contracting with Instrumental Research to evaluate their substrates for methane potential using the equipment and procedures developed during this study.

ENGINEERING STUDY

The engineering feasibility study was conducted in parallel with the experimental phase of this project and laid out a regional biogas concept using mixtures of hog manure and corn stover. The primary conclusions of the engineering study include:

There is no technical barrier to digestion of large volumes of hog manure/biomass blends. Even operations with up to 20,000 hogs on site would be smaller than the digesters now operating on dairy farms in Wisconsin.

The harvesting technology for baling corn stover is commercially available and has known costs and yields per acre.

The total stover required for a 20,000 hog operation could be harvested from 860 acres.

Capital investment per standard cubic foot of methane per hour (SCFH) declines sharply with scale. For a 5000 hog operation, the capital cost is \$713 per SCFH of methane production compared with \$363 per SCFH for a 20,000 hog operation.

Assuming average operation of 350 days per year, a SCFH of capacity is expected to produce approximately 8500 cubic feet of methane annually. At current markets, this methane has a market value from \$8 to \$12 per thousand cubic feet. Simple payback for the larger operations is expected to be from 5.3 to 3.6 years.

Pretreatment of biomass to promote digestion may represent an opportunity to create a new business in rural Minnesota. Under this model, biomass would be harvested, liquefied or otherwise made available for digestion and then distributed to hog operations to supplement biogas production.

LOOKING BACK

In retrospect it is now clear that the results of this study would have been greatly enhanced if the digestibility of raw biomass had been anticipated. Various methods for pretreatment are available including acid hydrolysis and fungal digestion. Funding was not adequate to add this to the study, however, and we were limited by the scope of the original project.

Budget for Result 1:

| | Personnel | Equipment | Other | Total |
|-------------|-------------|-------------|----------|-----------|
| Grand Total | \$50,000 | \$20,000 | \$30,000 | \$100,000 |
| Spent | \$44,786.57 | \$19,999.09 | \$30,000 | 94,785.66 |
| Balance | \$ 5,213.43 | \$ 0.91 | 0 | \$5214.34 |

When the experimental data showed that the biomass would not produce gas without pretreatment, the engineering study was reduced in scope to summarizing the progress to that point. This conserved about \$5000 of engineering money.

Completion Date: *June 2007*

Final Report Summary:

V. TOTAL LCMR PROJECT BUDGET:

TOTAL LCMR PROJECT BUDGET: \$100,000

| Project Partner | Personnel | Equipment | Other | Total |
|----------------------------|-----------|-----------|----------|-----------|
| Sebesta Blomberg | \$25,000 | \$20,000 | | \$45,000 |
| Instrumental Research Inc. | \$25,000 | | \$30,000 | \$55,000 |
| Grand Total | \$50,000 | \$20,000 | \$30,000 | \$100,000 |

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

Approximately \$20,000 has been allocated for the construction of lab scale digesters. This will require the construction of approximately 30 gallon vessels equipped with temperature control, agitation and gas collection systems.

VI. OTHER FUNDS & PARTNERS:

A. Project Partners:

Staffing for this project is estimated to consist of approximately ¼ time for one person for one year at Sebesta Blomberg. Staffing at Instrumental Research will be ¼ time for one person for one year as well.

Equipment purchases will include up to 4 anaerobic digesters of 5 to 10 gallons each built from clear Plexiglas®. Each digester will be equipped with temperature control, gas collection bags and addition and removal ports.

Expenses under the "Other" classification will include sample materials, analytical equipment use and analytical reagents.

B. Other Funds being Spent during the Project Period:

- a. The Minnesota Department of Commerce has agreed to provide staff support equivalent to 5% of one person's time to this project. The estimated value of this staff support is \$4,500.
- b. Sebesta Blomberg and Associates provided office facilities, communications and computer systems valued at \$10,000 for this project.

C. Required Match (if applicable):

D. Past Spending:

E. Time: This project was completed June 2007

VII. DISSEMINATION: The dissemination of the results of this work is to be planned in cooperation with the Minnesota Department of Commerce. Sebesta Blomberg maintains a web site that can be used for dissemination of project results.

VIII. REPORTING REQUIREMENTS:

Periodic work program progress reports will be submitted quarterly with the first report due on September 30, 2005 and repeating on three month intervals thereafter until the completion of the work or May 2007 whichever occurs first.

IX. RESEARCH PROJECTS:

See research protocol

Attachment A: Budget Detail for 2005 Projects - Summary and a Budget page for each partner

Proposal Title: *Natural gas production from agricultural biomass*

(E-05)

Project Manager Name: *Cecil Massie*

LCMR Requested Dollars: \$ 100,000

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 | <u>Result 1 Budget:</u> | <u>Amended Budget</u> | <u>Amount Spent</u> 6/30/07) | <u>Balance</u> 6/30/07 | |
|--|--|-----------------------|---------------------------------|---------------------------|------------------------------|
| | Demonstrate gas production potential of hog manure/biogas blends | | | | |
| BUDGET ITEM | | | | | TOTAL FOR BUDGET ITEM |
| PERSONNEL: Staff Expenses, wages, salaries – Be specific on who is paid \$, to do what? Make each person paid a separate line item | | | | | |
| Cecil Massie/Sebesta Blomberg will oversee operation of the digesters and process engineering | \$ 25,000 | \$ 23,000 | \$ 17,787.51 | \$ 5,212.49 | \$ 23,000 |
| PERSONNEL: Staff benefits – Be specific; list benefits for each person on a separate line item | | | | | |
| Contracts | | | | | |
| Professional/technical (with whom?, for what?) | | | | | |
| Delman Hogen/Instrumental Research will provide technical support for digestion and analytical services | \$ 25,000 | \$ 27,000 | \$ 26,999.06 | \$ 0.94 | \$ 27,000 |
| Other direct operating costs (for what? – be specific) | | | | | |
| Analytical services, sample materials and analytical reagents | \$ 30,000 | \$ 30,000 | \$ 30,000.00 | \$ - | \$ 30,000 |
| Equipment / Tools (what equipment? Give a general description and cost) | | | | | |
| Pilot scale anaerobic digester(s) equipped with flow controls, temperature control and gas collection equipment | \$ 20,000 | \$ 20,000 | \$ 19,999.09 | \$ 0.91 | \$ 20,000 |
| COLUMN TOTAL | \$ 100,000 | \$ 100,000 | \$ 94,785.66 | \$ 5,214.34 | \$ 100,000 |