

CONSERVATION INNOVATION GRANTS

Final Report

Grantee Name: Giziibii Resource Conservation & Development Association (RC&D)	
Project Title: Power from the Prairie – Demonstration & Evaluation of Burning Agricultural Waste Streams in a Small-Scale Gasifier	
Agreement Number: NRCS 69-3A75-7-126	
Project Director: Brent Benike	
Contact Information: George Swentik, Giziibii RC&D Chair, 3217 Bemidji Ave N, Bemidji, MN 56601	Phone Number: 218-751-1942 x 5 E-Mail: mnbemidji-rcd@one.usda.gov

Project Activities

The development of the *Power from the Prairie – a Biomass Gasification Pilot* project began with a kickoff meeting of the project partners on May 7, 2008 at Northern Excellence Seed, LLC in Williams, Minnesota. Partners on the project included: Northern Excellence Seed, LLC (NEX), Giziibii Resource Conservation and Development Association (GRCD), Energy and Environmental Research Center (EERC), Agriculture Utilization and Research Institute (AURI), Minnesota Turf Growers Association, and Pembina Trail Resource Conservation and Development Association. The EERC engineer assigned to the project presented a project schedule outlining the timeframe expected to complete the project. Project tasks were arranged in the following categories and are addressed in this section of the report: Site Preparation, Engineering, Procurement, Startup, Training, and Operations.

The biomass demonstration project also contained an energy crop pilot component. A detailed report of the project has been developed and will be shared with project partners and others interested in the use of Perennial grass crops for biomass production.

Site Preparation

Site preparation involved the following: permitting, electrical services, sewer inquiry, site layout and offset, building procurement, concrete work, and an electric agreement. Northern Excellence was awarded \$200,000 in Next Generation grant funds from the Minnesota Department of Agriculture to offset the cost of the site work and Lake of the Woods County contributed \$30,000 to the construction of the building (see budget outline for specific dollars

spent). Work was contracted and completed prior to the gasification system arriving at the plant.

EERC was responsible for submitting a report to the Minnesota Pollution Control Agency (MPCA) to determine the applicability of an air quality permit for the project. MPCA reviewed the report that was submitted and provided a formal letter indicating exemption from air quality permitting and monitoring. A copy of the engineering record indicating the findings of the MPCA has been filed and a copy is also kept on-site.

Ground preparation and building construction was completed by local contractors selected by Northern Excellence Seed. The building was laid out and constructed, following the recommendations of the EERC engineer, behind the seed cleaning facility at a safe offset. The building is only accessible to trained personnel. Carbon monoxide detectors were installed in the building for safety since carbon monoxide is produced by the system. Discussion by the project team has led to an investigation into the addition of an externally read carbon monoxide detecting system. This option is being pursued by the Northern Excellence Board of Directors.

An electric rate agreement was completed by Northern Excellence with local and regional utility companies. Northern Excellence met with the local electric utility, Northstar Electric, a member-owned cooperative, and the regional energy supplier, Minnkota Power, to negotiate a power purchase agreement. A renewable energy rate of 5.25 cents/kW for the power produced was granted to Northern Excellence by the utility. Northern Excellence Seed continues to work with the power companies to establish a higher renewable energy rate.

Engineering

Giziibii RC&D entered into an agreement with the EERC to complete the engineering and implementation of the gasification system. The process designed by EERC includes fuel storage and handling, gasification, gas-cleaning, process residual handling, and power generation. The process is designed to produce 100kW of power in parallel with the utility at a fuel consumption rate of 5 tons/day.

A day bin or silo capable of storing one week of fuel was equipped with a Flying Dutchman auger to store the fuel for the gasification process. The auger system is designed to keep the flow of seed screenings constant into the system. An enclosed conveyor, designed to keep moisture out, is located at the base of the bin to transport the screenings from the storage bin into the burner.

The gasification process procured by the EERC converts solid fuels to gas. The flow of air is limited to the fire inside the gasifier causing the gas exiting the gasifier to be rich in combustible

gases. The low Btu gas, composed mostly of Hydrogen and Carbon Monoxide, is referred to as “syn-gas” or “producer gas” and is used by the system to produce energy.

Following gasification the syn-gas is sent through a cleaning process. During this process the gas passes through two screens or filters. The first filter is changed once every week or every other week depending on use and the second filter is changed once per month. Water is also used during this process to scrub the gas with condensate build up flowed to the burner for disposal.

The process residual handling is the burner unit located outside the building housing the gasification unit. The burner produces 10% ash equivalent to 1,000 pounds/day or one drum per eight hours of operation.

After the gas undergoes the filtering and scrubbing processes, it is burned in a natural gas generator modified to fire the low-Btu gas to produce electricity. The emissions produced by the generator, in comparison to natural gas combustion, contain less particulates and cancer causing carcinogens and are within Minnesota Pollution Control Agency regulations.

A programmable logic controller was designed by EERC to provide automatic control, monitoring, and automatic shutdown allowing the process to operate unattended. The controller will allow Northern Excellence to run the system 24 hours/day during peak seed cleaning. During plant downtime the system can be shutdown and screenings stored in the day bin for future use.

Procurement

Procurement of equipment and services was conducted by EERC and Northern Excellence. Fabrication of the feed system, gasifier, gas cleanup, residual handling, controls, engine, switchgear, and instrumentation was done off-site. The gasifier was assembled on a skid frame at the EERC and transported to the Northern Excellence facility for installation. The gasifier system was assembled by EERC engineers upon arrival at the plant. Information related to the manufacturers and suppliers of the equipment is proprietary information of the EERC. Individuals wishing to learn more can contact EERC for further information.

Startup

Initial startup of the gasifier was projected for March 2009. The start date was extended throughout the duration of the project due to delays in equipment procurement. The gasifier system was fired using woodchips and grass screenings as the fuel source in an initial test of the system. The initial test, November 2009, proved to be successful in producing gas and electricity with minor problems from the production of gas to generation of electricity.

The first problem identified was fine particulate matter was passing into the system from the burner unit. Unburned seed screenings and fine ash particles passing into the system with the gas resulted in plugged filters at the start of the gasification process. The EERC has designed screens, to collect the fine particulates, which will be fabricated and installed in the burner unit February 2010.

The second problem identified was on the power output end of the system. The generator was able to be paralleled to the grid, but the Switchgear was not able to communicate with the throttle-body governor controller resulting in electrical production of 30kW under manual control. EERC has contacted the engine manufacturer to troubleshoot the problem and has a work order in place for a redesign of the throttle-body.

Training

EERC will provide training to the staff at Northern Excellence following the restart of the gasifier system. Staff will be trained on the process of cleaning the burner and changing the filters in the system. They will also be trained on safety aspects of the system and troubleshooting potential problems. Training will be provided both on-site and through verbal and written communication between Northern Excellence and EERC.

Operations

The gasification system is currently inefficient to operate. Operation will resume following the installation of the screens and the throttle-body component. EERC will be on-site to operate the gasifier following the fixes to ensure all issues have been addressed. Upon successful operation of the system and staff training system operations will be the sole responsibility of Northern Excellence personnel.

Energy Crop Pilot

The energy crop pilot study was completed with assistance from Dr. Dave Grafstrom, instructor with Northland Community and Technical College. The objective of the study was to evaluate technical, environmental, and financial assessments of Perennial crop residues and other biomass sources in the conversion of plant material into energy. Information collected in the field study included: cost and returns of Perennial grass seed production, biomass quantity (ton/acre) produced, biomass quality (Btu's/acre) produced, costs and returns of the biomass produced and a complete financial analysis to determine the value for various sources of biomass.

Environmental Quality Incentives Program (EQUIP) eligible producers (in Lake of the Woods and Roseau Counties) who raise Perennial grass seed crops, entered into a contract with Giziibii

RC&D to assist in the field portion of the project in exchange for a \$150/acre incentive payment. The producers also completed a Farm Business Management course to study the basic principles of gasification technology and how that technology can benefit individuals and communities. Dr. Grafstrom served as the class instructor. The class included both classroom and one on one instruction. Giziibii RC&D was able to cover the cost of tuition for the fifteen producers with a \$5,000 grant awarded by the Clean Energy Research Team.

Two hundred acres of Perennial ryegrass and Kentucky bluegrass were studied during the 2008 and 2009 growing seasons. Producers baled their straw after seed harvest on selected plots. The bales provided an estimate of the tons of plant material available to be utilized for biomass. Core samples from 20% of the collected bales were extracted, pooled, and subsamples were submitted to the Stearns County DHIA forage lab for analysis. The samples were analyzed as follows: nutritional value from the biomass if fed to livestock, nutritional value if the straw was returned to the soil (N, P, K), and the value of the ash that remains if residue is burned. The NDFD-OARDC-SUGAR test was used to determine the relative forage quality if fed to livestock and an assessment of crude protein and a wet chemistry test for nitrogen, phosphorus, and potassium was conducted on the straw and ash samples.

The results of the study were presented in a formal report to Giziibii RC&D by Dr. Dave Grafstrom and are shared below. Further testing and analysis will be conducted to compare the laboratory results presented to the results produced in a production scale gasifier system following the installation of needed components and system restart.

Funding Received and Expended

Funding Received - Federal

Conservation Innovation Grant to Giziibii RC&D	\$229,700
TOTAL FEDERAL FUNDS RECEIVED	\$229,700

Funding Received – non-Federal Cash Match

Minnesota Department of Agriculture Grant to Northern Excellence	\$200,000
Northern Excellence Seed Cash Contribution	\$75,000
AURI Board Cash Contribution	\$70,000
Lake of the Woods County Grant – gasifier building construction	\$30,000
Clean Energy Resource team Grant – energy crop producer class	\$5,000
TOTAL NON-FEDERAL FUNDS RECEIVED	\$380,000

Funding Received – In-kind Match

North Central Technical College – Dr. Dave Grafstrom – Salary and Benefits 2007 – 2009 – 1,132 hours @ \$45/hour - \$50,940	\$50,940
University of Minnesota – Dr. Derek Crompton – Salary and Benefits 2007 – 80 hours @ \$40/hour - \$3,200	\$3,200
Northern Excellence Seed – Brent Benike, Plant Manager – Salary, Benefits, and Travel 2007-2009 – 600 hours @ \$50/hour - \$30,000 and 1280 miles @ 0.50/mile - \$640	\$30,640
Northern Excellence Seed Board of Directors – Meetings and Travel 2007-2009 – 4 meetings/yr @ 1 hour/meeting for 6 members – 72 hours @ \$20/hour - \$1440 and 1280 miles to attend meetings @ 0.50/mile - \$640	\$2,080
Northern Excellence Seed – Staff – 90 hours @ \$15/hour - \$1350	\$1,350
Minnesota Turf Seed Council – Marv Zutz, Executive Director MN Barley Council – Salary and Benefits 2007-2009 – 250 hours @ \$60 - \$15,000	\$15,000
Giziibii Resource Conservation and Development Council (2007-2009) - 700 hours @ \$18.77/hour (Earth Team Volunteer rate) - \$13,139	\$13,139
TOTAL IN-KIND FUNDS RECEIVED	\$116,349

Project Expenses

EERC Salaries and Benefits	\$50,690.85
EERC Travel	\$6,755.68
EERC Supplies	\$1,492.11
EERC Printing/Graphic Support	\$1,360.44
EERC Communications	\$184.47
EERC Operating Fees and Services	\$951.92
EERC Freight and Administration	\$36,336.81
EERC Equipment	\$225,853.64
Energy Crop Producer Marketing Class - 15 producers Tuition	\$5,000
Site Preparation and Building Construction	\$18,972
Earthwork (site preparation)	\$4,297
Air System Reconfiguration	\$35,000
Electrical Interconnect	\$32,000
Northern Excellence Contracting and Additional Staffing	\$99278
Concrete – gasifier building	\$9,558
Materials – gasifier building	\$20,111.75
Dozing and Gravel (Class 5)	\$4,070
Conditional Use Permit	\$100
CIG Biomass Presentation – CIG Conference	\$1,474.98
Environmental Quality Incentives Program Producer Payments	\$30,000
DHIA Testing Lab	\$673.43

Tub Grinding Field Day	\$2,000
Environmental Quality Incentives Program Residue Testing	\$1,000
Northern Excellence Contracting Services (grant writing)	\$528.41
Operation and Maintenance	\$9,010.51
Public Relations	\$7,000
Indirect Costs – Giziibii RC&D	\$6,000
TOTAL EXPENSES	\$609,700

Federal Cash Expenses (from expenses shown above)

Environmental Quality Incentives Program Producer Payments – 15 producers @ \$150/acre	\$30,000
Indirect Expenses to Giziibii RC&D	\$6,000
EERC Equipment and Contractual Expenses	\$193,700
TOTAL FEDERAL CASH EXPENSES	\$229,700

Results

The *Power from the Prairie – Biomass Gasification Pilot* project had three primary components 1.) Attend at least one meeting hosted by NRCS 2.) Install a gasification system in Williams, Minnesota, and 3.) Conduct field studies to evaluate technical, environmental, and financial assessments of Perennial crop residues and other biomass sources in the conversion of plant material into energy. The deliverables of the project for the CIG award have been met and results presented.

George Swentik, Giziibii RC&D Council Chair, attended and presented project information at the 2008 CIG Showcase held in Tucson, Arizona, to meet the first deliverable required by the grant agreement. Mr. Swentik provided an oral presentation for the group outlining the demonstration project that was being constructed in Williams, Minnesota. Giziibii RC&D has submitted an abstract to attend the 2010 CIG Showcase in St. Louis, Missouri, to present the results of the project.

The gasification system has been installed at Northern Excellence Seed, LLC. The initial firing of the system identified two major issues that need to be addressed before the gasifier can continue to be used. Screens need to be installed between the burner and the gasifier to extract fine particles from the gas prior to entering the gasification system. A problem was also identified between the throttle-body governor controller on the generator and the switchgear. Until these problems are addressed the gasifier remains inoperable as originally designed. The

EERC is currently working on a solution to the problems encountered. They will complete the needed repairs and reconnect the gasifier to the electrical grid.

The results of the straw samples analyzed during the energy crop pilot field study are presented below. A formal report has been written and will be shared with others interested in biomass crop production.

Value of Kentucky bluegrass and Perennial ryegrass fed to livestock presented on a dry matter basis

	Kentucky Bluegrass	Perennial Ryegrass
Crude Protein	6.86%	5.17%
Total Digestible Nutrients	45.51	49.56
Relative Feed Value	64.49	72.05
Phosphorus	0.23%	0.19%
Potassium	1.16%	1.09%
Ash Content	6.24%	5.98%
% Moisture	13	22

Relative feed value is a common measurement used to value forage. Premium grade forage will have a relative feed value of over 170 and utility grade forages will have a relative feed value of less than 130. Based on the lab results shown Kentucky bluegrass and Perennial ryegrass would be on the low end of the utility hay grade market and may average \$20-\$40/ton.

Value of Straw Returned to the Soil

The nutritional value of the straw was determined by measuring the amount of Nitrogen, Phosphorous, and Potassium in Kentucky bluegrass and Perennial ryegrass straw. A cost comparison was completed using the results versus the cost of commercial fertilizer.

Low and high prices of urea, phosphate, and potash in the last 5 years (2005-2010)

Nutrient	Low	Low	High	High
	\$/ton	\$/ton	\$/ton	\$/ton
Urea (46-0-0)	\$300	\$0.33	\$800	\$0.87
Phosphate (11-52-0)	\$350	\$0.34	\$1200	\$1.15
Potash (0-0-60)	\$200	\$0.17	\$800	\$0.67

Nutrient Content (N, P, K,) of Kentucky bluegrass and Perennial ryegrass

	Kentucky bluegrass		Perennial Ryegrass	
	#/acre	#/ton	#/acre	#/ton
Nitrogen	19.2	22.0	35.7	16.6
Phosphorus	4.0	4.6	8.17	3.8
Potassium	19.1	23.2	35.7	21.8

Value of N, P, & K in Kentucky bluegrass straw

Nutrient	Low	High	Low	High
	\$/acre	\$/acre	\$/ton	\$/ton
Urea (46-0-0)	\$6.30	\$16.70	\$7.30	\$19.10
Phosphate (11-52-0)	\$1.40	\$4.60	\$1.60	\$5.30
Potash (0-0-60)	\$3.20	\$12.80	\$3.90	\$15.50
Total	\$10.90	\$34.10	\$12.80	\$39.90

Value of N, P, & K in Perennial ryegrass straw

Nutrient	Low	High	Low	High
	\$/acre	\$/acre	\$/ton	\$/ton
Urea (46-0-0)	\$11.80	\$31.10	\$5.50	\$14.40
Phosphate (11-52-0)	\$2.80	\$9.40	\$1.30	\$4.40
Potash (0-0-60)	\$6.10	\$23.90	\$3.70	\$14.60
Total	\$20.70	\$64.40	\$10.50	\$33.40

The results shown above indicate that the nutritional value of the straw will vary with the price of fertilizer. If fertilizer prices are low the nutritional value of the straw is less compared to times of high fertilizer prices. The N, P, & K value of Kentucky bluegrass straw and Perennial ryegrass straw ranged from \$10.90 to \$31/acre and \$20.70 to \$64.40/acre respectively. The average nutritional value of the straw measured during this study is \$22.50/acre for Kentucky bluegrass straw and \$42.60/acre for Perennial ryegrass straw.

Value of Ash Remaining after Residue Burning

The average ash content of Kentucky bluegrass and Perennial ryegrass is 6.24% and 5.98% respectively. The analysis of the ash suggested that the plant nutrients in the straw were not lost due to burning and were available for plant use. However, field observations have shown that nitrogen left on the soil surface is readily lost to the environment soon after the burn and

should not be considered plant available, where as phosphorus and potassium appear to be more stable in the soil and can be considered plant available.

Value of Kentucky bluegrass and Perennial ryegrass as a Source of Biomass

The final analysis done on the straw samples was to determine the value of Kentucky bluegrass and Perennial ryegrass straw as a source of biomass. Laboratory analysis, conducted by AURI, on the straw samples indicates bluegrass and ryegrass straw have potential as biomass crops. Kentucky bluegrass and Perennial ryegrass compared favorably to wood pellets in energy production. The table below shows the laboratory results of the study.

	Bluegrass straw	Ryegrass straw	Wood Pellets
Moisture	7.0	6.73	4.31
Ash	5.64	4.7	1.86
BTUs/ton	7,033	7,165	7,941

Source: AURI

Potential for Transferability of Results

The *Power from the Prairie – A Biomass Gasification Pilot* project was designed to demonstrate the use of a small scale gasifier to produce electricity. The project was aimed at demonstrating the potential of small scale gasification plants and the benefits associated with their use to individuals and communities. Groups interested in receiving project results for replication will be encouraged to talk with the project partners and to work with the EERC to learn more about the inner workings of the gasification system.

Current methods of information sharing are through verbal and written communication. Several news articles were written about the project in its early stages to promote the project, as well as, the Natural Resource Conservation Service, the Conservation Innovation Grants program, and, the Giziibii Resource Conservation and Development Council. News articles will be produced with the project results identified thus far and will be shared with news media across the nation, including but not limited to, local, regional, national, and scientific venues.

A gasifier brochure has been developed by the EERC for public distribution. Giziibii RC&D will be responsible for the printing and distribution of the information. Brochures will be made available at the gasifier site and will be distributed at workshops, conventions, and gatherings that the RC&D and other partners are exhibiting at. Darren Schmidt, EERC Engineer assigned to the project, has also developed a fact sheet highlighting key information about the gasification system to be shared with individuals while touring the system onsite. The internal workings of

the gasifier system are proprietary information and will only be available for release by EERC personnel.

A ribbon cutting ceremony and open house will be used to promote the onsite results of the gasification project. Gasifier demonstrations will be conducted by the partners involved in the project to allow interested individuals a chance to see the system working. Project partners will be onsite to answer questions and demonstrate the gasification process. Giziibii RC&D will be working with the Northern Excellence staff and members to develop a plant tour schedule for future visits by interested groups and individuals.

Conclusion

The *Power from the Prairie – a Biomass Gasification Pilot* project serves as a demonstration of the availability of biomass utilization on a small scale to individuals and groups. The gasifier system is currently inefficient to operate as originally designed. EERC engineers and the project partners are working to correct the flaws in the design in an effort to complete the project with positive results. Follow-up funding is being sought for technical assistance, operation, and maintenance of the system. Giziibii RC&D along with the project partners will continue to work with Northern Excellence Seed to secure funding to keep the gasifier operational.

The biomass energy crop component of the project has proven that perennial grass seed crops have potential to serve as sources of biomass in gasification systems to produce electricity.