DOE/GO/10148-4
Dis. Category UC

BIOMASS POWER FOR RURAL DEVELOPMENT

Quarterly Report for the Period
July 3 - December 4, 1997

James T. Cooper

CHARITON VALLEY
RESOURCE CONSERVATION & DEVELOPMENT, INC.

Date Published - March 1998

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY
Under Cooperative Agreement
No. DE-FC36-96GO10148

DISCLAIMER

CHARITON VALLEY
RESOURCE CONSERVATION & DEVELOPMENT

RR 3, BOX 116A
CENTERVILLE, IA 52544
Ph: 515/437-4376 e-mail: cvrcd@se-iowa.net Fax: 515/437-4638

TABLE OF CONTENTS

INTRODUCTION

This report is a combination of two quarterly reports, July 3 to October 3, 1997 and October 4, to December 4, 1997. This combination was done in order to help bring the project reporting requirements up to date. The period was filled with informational meetings, both to deliver information, and to receive information. Those meeting included the DOE Semi-Annual Biomass Program Review Meeting in Denver, Colorado, Third Biomass Conference of the Americas in Montreal, Quebec, Canada, Iowa Quarterly Biomass Stakeholders Meeting in Des Moines, Iowa, the DOE's Bioenergy Feedstock Development Program in Stillwater, Oklahoma, as well as several other smaller meetings. One highlight of the period was the project visit by Secretary of Agriculture Glickman.

The project continues to pick up momentum as more organizations and individuals hear of the many benefits of closed-loop biomass energy production. The potential benefits of the project have attracted people with water resources and soil erosion interests, wildlife management and now, with the Kyoto summit concluded, the major benefits of global atmospheric carbon mitigation rise in importance. These, combined with the overshadowing rural economic development benefits, increase the likelihood of the project being commercially viable in the shorter term.

The facts found in the last quarter from the site visits in Denmark are finding their way into the project planning and facilities design. The design process and switchgrass procurement process continue to develop as we learn more, and change to accommodate better ideas and increasing knowledge.

SWITCHGRASS CONVERSION DEVELOPMENT

A meeting of the switchgrass conversion sub group was held July 8, 1997 at the Cedar Rapids, Iowa office of the IES, Inc. (IES) headquarters. The meeting was attended by Doug Alexander and Gary Walling of IES, Conrad Anderson of RW Beck, Jim Cooper and Marty Braster of Chariton Valley RC&D (RC&D) and Ed Woolsey of E. L. Woolsey & Assoc. Discussions were held concerning the need for, and requirements of, a co-fire test. Discussions were held on the current projected timeline for the co-fire, given the lag time for design/construction and acquisition of the switchgrass bales. Current plans call for the test burn to occur either fall or spring of 1999. We expect the test to last four to five days and require approximately 2,000 tons of switchgrass.

Plans were discussed concerning the operating agreement which will develop between RC&D and IES. The idea of "tolling" was discussed. Tolling would occur if IES allowed project switchgrass to be burned in their boiler with the resulting corresponding electricity returned to the project. IES would charge the project a set amount per ton or per kilowatt hour for the conversion. The resulting "green" electricity would then be marketed by the project.

The current economic situation of the switchgrass and coal co-fire strategy was raised. It is suggested that the biomass energy may be competing with wind as a least cost "AEP" feedstock source. The economic impacts of the clean burning properties of switchgrass were discussed and evaluated. It was agreed that these advantages needed to be quantified and a method found for their internalization into the project scenario.

IES estimates that our switchgrass has a value of approximately $35 per ton on a coal equivalency basis.

RW Beck and IES will begin conversations with ABB as soon as possible concerning the boiler modifications which will be required.

RW Beck has developed a "Preliminary Draft-Switchgrass Co-Firing Test Protocol". *(Attachment One)* The draft protocol outlines the switchgrass procurement and the co-firing timetables along with some more detailed cost estimates. The draft begins to detail some of the logistics required for the co-firing test. In order to take advantage of the knowledge gained by the Danish efforts in this technology, ELSAMPROJEKT of Denmark has been asked to submit a proposal to provide assistance to the project. *(Attachment Two)* This contractual relationship will continue to be developed between RW Beck, the project, and the DOE.

SWITCHGRASS GASIFICATION DEVELOPMENT

The period has been occupied with continued development of a material handling system for switchgrass, design and procurement of a new ignition system for gasifier start-up, analysis of switchgrass for trace elements, and participation in the Third Biomass Conference of the Americas. A summary of each of these activities is described below.

Development of a material-handling system for switchgrass is continuing. After modifications to every part of the material handling system, a functional configuration has

not yet been identified. The configuration of a live-bottom, twin-screw feed hopper works well and the high speed (120 rpm) injection system works well, however, hot gas bypass of the airlock is the biggest concern. The original airlock, which has steel vane tips with a tight tolerance, had a tendency to plug due to switchgrass caught between the vanes and the airlock wall. Knives on the vanes would help alleviate this problem, but this type of airlock is extremely expensive. A ten inch airlock utilizes rubber flaps to make the air seal. This design is not as effective as steel vanes for preventing back-flow of gases but is more tolerant of stringy biomass materials.

Danish experience of straw feeding into small, slightly pressurized reactors, suggest that a plug maker may be the feeding method of choice. A plug is formed near the entrance to the reactor by slightly constricting the flow path. We have tried this approach and it seems to be an effective feed method which also prevents the back flow of hot gases. However, the original injection system was not powerful enough to maintain switchgrass flow through the plug. Therefore, a more powerful drive system will be purchased to enable use of a plug-feed type system. If this is successful, it will eliminate the need for an airlock.

Modifications to the fluidized bed reactors start-up equipment are also taking place. The original ignition system consists of a transformer which supplies high voltage to a pair of electrodes which produce an arc internal to the reactor. This arc ignites the air/natural gas mixture for initial reactor heating. Problems were encountered with the electrodes becoming fouled with bed material thereby disrupting the arc so ignition was lost. To alleviate this problem, a new natural gas flare ignition system is being installed. It is believed this new configuration will ignite the premixed air/natural gas stream but avoid the fouling problems associated with the original ignition system.

A detailed analysis of the switchgrass was performed. The analysis may be found in *Table 1*. This analysis is valuable for several reasons. First, the analysis was performed on unashed samples. This is important because many trace elements of concern (i.e., chlorine, sodium, potassium, etc.) may volatilize during ashing and therefore would not be accounted for in an analysis of the ash. Second, identification of contaminants in the an unashed sample of biomass will give an indication of what clean-up methodologies will need to be developed, depending on the end use of the producer gas. For example, if the gas is to be utilized in a fuel cell, contaminants of interest include sulfur, chlorine, arsenic, selenium, zinc, and lead. If these constituents are not found in the original switchgrass sample then there is no need to develop gas clean-up for their removal. Standards (apple

leaves and pine needles) were analyzed as unknowns for quality control purposes. The certified values are listed adjacent to the analyzed values.

Table 2 is an analysis of switchgrass ash. The ash was generated by heating the original sample to 480 0C (896 0F). A comparison between the trace elements of interest (i.e., potassium) from the original sample and the ashed sample show little change due to the ashing process. This is expected as the ashing temperature was not hot enough to volatilize a significant portion of the trace elements of interest. Unfortunately there is not information in the ash analysis on chlorine, sulfur, or lead content which are all elements of interest. Studies on straw conducted at the Danish Technological Institute suggest that at 480 0C only 10% of the alkalis and 15% of the chlorine will volatilize. These percentages will increase with increasing temperature to values of approximately 40% alkali release and 80% chlorine release at 740 0C (1364 0F).

Table 1. Analysis of original biomass samples (unashed).

Element	Units	Detection Limit	SWITCH GRASS	APPLE LEAVES	certified values	PINE NEEDLES	certified values
Au	PPB	0.1	< 0.1	0.4	[0.001]	1.4	
Ag	PPM	0.3	< 0.3	<0.3		<0.3	
As	PPM	0.01	0.1	0.17	0.038	0.19	0.21
Ba	PPM	5	20	50	49	6	
Br	PPM	0.01	12	2.1	[1.8]	6.8	[9]
Ca	%	0.01	0.28	1.53		0.42	0.41
Cd*	PPM		<0.5	<0.5	13	<0.5	<0.5
Cl	PPM		681	605	579	465	
Co	PPM	0.1	0.1	0.1	[0 09]	0.2	
Cr	PPM	0.3	1.8	1.1	[0 3]	2.7	
Cs	PPM	n.OS	< 0.05	<0.05		0.12	
Fe	%	0	0.012	0.008	0.0083	0.021	0.020
Hf	PPM	0.05	< 0.05	0.05		<0.05	
Hg*	PPB	1	13	106	44	39	150
Hg	PPM	0.05	< 0.05	<0.05	0.044	0.12	0.15
Ir	PPB	0.1	< 0.1	<0.1		<0.1	
K	%	0	0.384	1.62		0.34	
Mo	PPM	0.05	0.3	0.08	0.094	<0.05	
Na	PPM	0.5	16.3	24.4	24.4	36	
Ni	PPM	2	<2	< 2	0.91	< 2	[3 5]
Pb*	PPM		o	7	470	3	10.8
Rb	PPM	1	6	10	10.2	11	
S	%		0.09	0.15		0.15	
Sb	PPM	0	0.007	0.02	[<0.2]	0.16	
Sc	PPM	0.01	0.02	0.03		0.03	
Se	PPM	0.1	< 0.1	<0.1	0.05	<0.1	
Sr	PPM	10	17	< 10	25	30	4.8
Ta	PPM	0.05	< 0.05	< 0.05		<0.05	
Th	PPM	0.1	< 0.1	<0.1		< 0.1	0.037
U	PPM	0.01	< 0.01	< 0.01	[0.006]	0.01	0.02
W	PPM	0.05	< 0.05	<0.05	[0.007]	<0.05	
Zn*	PPM		10	26	12.5	26	
Zn	PPM	2	14	11	12.5	59	
La	PPM	0.01	0.12	25	[20]	0.2	[0.2]
Ce	PPM	0.1	0.1	3		0.3	
Nd	PPM	0.3	< 0.3	17		<0.3	
Sm	PPM	0	0.012	2.8		0.023	
Eu	PPM	0.05	< 0.05	0.23		<0.05	
Tb	PPM	0.1	< 0.1	0.3		<0.1	
Yb	PPM	0	0.013	0.212		< 0.005	
Lu	PPM		<0.001	0.024		<0.001	

Notes: Bracketed values of the standards are not certified.
Analysis perfommed by neutron activation for most elements
* - altemate analysis used for detemmination

Table 2. Analysis of ashed biomass samples.

Element	Units	Detection Limit	SWITCH GRASS	FLYASH	certified values
% ash in onginal sample			~5.494		
Au	PPB		<5	<5	
Ag	PPM	2	<2	<2	
As	PPM	0.5	1.5	145	145
Ba	PPM	10	288	1400	1500
Br	PPM	1	77	<1	
Ca	%	0.2	4.9	3.8	1.11
Co	PPM	1	3	46	46
Cr	PPM	1	30	200	196
Cs	PPM	0.5	0.6	11	11
Fe	%	0.05	0.22	9.69	9.4
Hf	PPM	0.5	0.6	9.7	[8]
Hg	PPM	1	<1	<1	0.16
Ir	PPB	2	<2	<2	
K	%	0.05	6.16	2.6	1.88
Mo	PPM	2	6	28	[29]
Na	PPM	10	470	1700	1700
Ni	PPM	50	<50	150	127
Rb	PPM	5	95	130	131
Sb	PPM	0.1	0.2	6.6	[6.8]
Sc	PPM	0.1	0.7	43	[40]
Se	PPM	2	<2	11	10.3
Sr	PPM	o	<300	870	830
Ta	PPM	300	<1	2	[2]
Th	PPM	0.5	0.6	25	24.7
U	PPM	0.1	<0.1	10	10.2
W	PPM	0.1	<1	<1	[57]
Zn	PPM		300	280	220
La	PPM	20	2	88	[84]
Ce	PPM	0.1	4	193	[180]
Nd	PPM	3 5	<5	81	[74]
Sm	PPM	0.1	o	17	[17]
Eu	PPM		o	4	4
Tb	PPM	0.01	<0.5	2.9	[2.5]
Yb	PPM	0.5	0.2	9.7	[7.4]
Lu	PPM		<0.05	1.48	[1.12]

Notes: Missing elements if interest include chlorine (Cl), lead (Pb), and sulfur (S)
Ashing \was perfommed at 480 C
Analysis perfommed by neutron activation

Dr. Robert Brown and Jerod Smeenk attended the Third Biomass Conference of the Americas in Montreal, Quebec, Canada, August 25-28, 1997. Dr. Brown presented a poster entitled "Catalytic Effects Observed During the Co-Gasification of Coal and Switchgrass", while Jerod Smeenk presented oral and poster representations entitled "Evaluation of an Integrated Gasification/Fuel Cell Power Plant". Both topics were well received.

Future work includes continued development of the material feeding and injection system for switchgrass. Testing will resume when an operational system is in place. Gas analysis will be performed to determine undesirable producer gas constituents. A new ignition system will be installed for reactor start-up. Further analysis of switchgrass will take place to determine temperatures at which alkalis and chlorine volatilize. Status Assessment and Forecast: On schedule.

PRODUCTION ACTIVITIES

Soil Studies

The long-term impact of switchgrass production for energy promises to have wide ranging impacts on soil and water migration and formation in the local drainage basin. In order to gain needed information on those impacts the Chariton Valley RC&D staff and partners have written a grant proposal to the Lockheed Martin Corporation, "Switchgrass Production in Iowa: Economic Analysis, Soil Suitability and Variety Performance." *(Attachment Three)* If selected the project will continue through September 1999.

In order to better understand the environmental interactions which will occur with large scale conversation to switchgrass the RC&D working with funding from Oak Ridge National Laboratories has negotiated a cooperative agreement *(Attachment Four)* with Iowa State University. The agreement will provide for research to:

- "determine the effect of soil variability and environmental quality on switchgrass production" and;
- "evaluate and develop switchgrass and reed canary grass germ plasm for bioenergy production, biofuel characteristics, and adaptation to Iowa.

While not funded by the DOE, the research will provide valuable information which should lend support to the overall objectives of the project. A more detailed explanation of the research can be found in the attached copy of the agreement.

Carbon Studies

The rising issue of Global Climate Change increases the necessity of a better understanding of switchgrass' role in carbon storage. The project is currently in the process of assembling a group of advisors with expertise in the field. It is felt that the issue will continue to grow in importance and the project has potential to have large impacts on how agriculture reacts to the issue of climate change.

We have working arrangements with soil scientists at Iowa State University and atmospheric scientists at the University of Iowa. We will be forming a Carbon Working Group in the next quarter and will be implementing field test protocols.

Switchgrass Production Economics

The economics of switchgrass production could be the most important single factor in the success of switchgrass as a dedicated biomass crop. In order to better understand the real costs associated with switchgrass production, the RC&D. has entered into an agreement with Dr. Mike Duffy of the Iowa State University Department of Economics. *(Attachment Five)*

Watershed Impacts

The majority of the project is located in what is known as the "Rathbun Lake Watershed". Rathbun Lake is one of the most important water resources in Iowa. The lake supplies the Rathbun Regional Water Association (RRWA), one of the largest rural water systems in the nation. As the project progresses, the impact of the change in land management to a system of less pesticides and less erosion will likely have a positive impact on the water quality of the RRWA. An overview of the Rathbun Lake Watershed Project has been included at the end of this report. *(Attachment Six)* It is included to inform the reader of the wide ranging positive "external" impacts the project will have in the region.

Prairie Lands Bio-Products

Prairie Lands Bio-Products, the not-for-profit organization was formed to act as the coordinating entity for the growth, processing and delivery of switchgrass. Prairie Lands holds meetings the first Monday of every month.

On September 17, 1997, members of the group traveled to Minnesota to visit a saw dust densification facility. The process of densification is of interest to the group because it offers the opportunity to market switchgrass as an energy feedstock to smaller conversion units. The switchgrass may be able to compete economically with propane, offering an immediate market for switchgrass. The densification operation was built by Mr. Andy Lee of Minnesota and was operating on waste saw dust. The Prairie Lands members discussed equipment cost, operating difficulties and the potential ability of the equipment to operate on switchgrass.

Accomplishments In The Field

- Baled 40 small square bales of switchgrass (SWG) off the Department of Natural Resources (DNR) ground to test for nutrient value as a baled forage and to see what affect this cutting will have on the biomass production in the fall.

- Evaluated the fertility test trial, the no-till conversion to SWG at the DNR area and on the CRP acres in Monroe and Lucas Counties. It appears that we will have acceptable stands in all areas. Moisture is a problem in some areas and may cause the loss of some seedlings.

- Alan Teel, Dr. Lee Burras, Dr. Charlie Brummer and four graduate students met to discuss the two project segments being handled by ISU. They visited the variety trial located south of Centerville. It appears we have lost that seeding this year because of the dry soil conditions. There are large cracks in the soil and rainfall was not sufficient to sustain the seedling growth.

- Saqib Mukhtar was contacted to discuss the possibility of starting a demonstration project to evaluate swine manure as a fertilizer on SWG.

- SWG was traded to Northwest Missouri State for some pellets. They have sent the material to the TVA for analysis.

- Evaluated the SWG stand on the fields at Iconium and the two converted fields that were seeded this spring. We have seedling establishment and some fields have plants six to twelve inches high.

- Two Lucas County producers have crop acres going into the Conservation Reserve Program (CRP) in 1998. Both will be planting SWG and will become a part of the project. They will have a total of about 40 acres.

- Were successful in the transfer of one semi-load of large square bales of SWG from our project to Tulsa, Oklahoma, to be used in a demonstration of the gasifier at Primenergy and possibly the use of the gas to fuel an internal combustion engine.

- Entertained a visit from Uffe Jorgenson of Denmark to learn more about our biomass project using SWG. He stayed in the Teel home, toured the project area and had an extensive visit regarding our project and how we might become involved in some of the biomass to energy work being conducted in his country. As a result, we will be sending some SWG seed for him to plant in a test plot to begin to develop a database of information on how SWG responds to cultivation in his country. He took some stems of SWG back with him to Denmark.

- Teel submitted an abstract to do a paper on the culture of SWG for Biomass to Energy Production to the "Biomass for Energy and Industry 10th European Conference and Technology Exhibition" to be held June 8-11, 1998, in Wurzburg, Germany.

- Meetings were held on two different occasions with DNR wildlife biologists and others, Jim Pease, Jim Wooley, regarding the implications of producing SWG for biomass on wildlife habitat. These meetings were very productive and will result in the addition of a "wildlife component" to our current management plan for all CRP acres. We will also be working with our local DNR wildlife biologist to evaluate some of our current CRP harvest sites for wild life habitat management suggestions.

- Two presentations were made at a "Value-Added Ag Products" conference held in Newton, Iowa. Title of the presentation was "Energy and Fiber Crops". The presentation was repeated twice. Total attendance at the conference was 158.

- Consulted one day with Dr. Dale Wolf from the University of Virginia regarding the establishment and production of SWG for biomass production. We visited our nitrogen fertility plots and discussed several issues regarding his research in establishment techniques.

- Evaluated 100 acres in Wayne County of SWG seeded in fall of 1996 for success of establishment. We found very few established plants except in certain locations. This field was seeded in November 1996 as a dormant seeding.

- Worked with five producers and signed up 565 acres of additional SWG for the project in Wayne and Lucas Counties.

INFORMATION AND EDUCATION

The project has generated many articles in state newspapers and several information publications have been developed. Copies of these documents are included in the Appendix. *(Attachment Seven)*

The single largest event during the period was the visit from Secretary of Agriculture Glickman. *(Attachment Eight)* Several other dignitaries attended the event including U.S. Senator Harkin, U.S. Congressman Boswell and others from the U.S. Departments of Energy and Agriculture.

DOE Semi-Annual Biomass Program Review Meeting

On July 16 and 17, 1997, the DOE held its Semi-Annual Biomass Program Review meeting. Jim Cooper and Ed Woolsey gave overview presentations at the meeting. Their presentation outlines were:

Jim Cooper	Introduction To Project	5 Min.
	Agronomic Aspect	5 Min.
	Environmental Component	5 Min.
	Biomass Growers Coop	5 Min.
Ed Woolsey	Conversion Component	
	IES Utility Co-Fire	5 Min
	Iowa State University Gasifier	5 Min.
	Oklahoma Combustion	5 Min.
	Small Scale Pelletizing	5 Min.
Questions/Answers	Jim and Ed	5 Min.

Iowa Sustainable Energy For Economic Development

On July 29, 1997, Ed Woolsey attended a meeting of the ISEED (Iowa Sustainable Energy for Economic Development) organization as a member of the Board of Advisors. ISEED is a statewide coalition organization currently representing over 150,000 members. The mission of the coalition is to increase the use of renewable energy and energy efficiency in the state.

The Director of the Office of Consumer Advocate was in attendance and discussed the current lack of economic environmental externalities in the consumer cost of electricity. The Investor-Owned Utilities have formed a State organization, the "Iowa Industrial Energy Group Inc." The group will be pushing the deregulation issue and have prepared an economic report for this year's state legislature detailing the benefits of deregulation. The Iowa Utility Board has held nine town meetings in the State to gather information of feelings towards electric competition. Utilities are currently supporters of "deregulation" but expect it to come with a renewable portfolio standard attached. The issue of deregulation has not been addressed yet by the project. We will be studying the positive and negative impacts surrounding the project in the near future.

Third Biomass Conference Of The Americas In Montreal, Quebec Canada

August 24-29, 1997, was the Third Biomass Conference of the Americas in Montreal, Quebec, Canada. Several members of the Chariton Valley Biomass Power Group attended, prepared and gave presentations. *(Attachment Nine)* Those who gave presentations included; Dr. Charlie Brummer, Dr. Robert Brown and Mr. Jim Cooper. The presentations were well attended and many good questions were asked and answered.

Many good professional contacts were made. One particularly important contact was Ms Rotroff from the law firm of Gomel & Davis of Atlanta, Georgia. Ms Rotroff is a partner of Greg Sanderson. Sanderson is one of the leading attorneys experienced in Section 45 closed-loop biomass tax credits. Rotroff and company are willing and eager to help our group develop the economic and legal parameters associated with the project commercialization.

Gomel & Davis LLP
700 Marquis Two Tower
285 Peachtree Center Avenue, N.E.
Atlanta, Georgia 30303-1230
Phone (404) 223-5900 Fax (404) 524-4755

Iowa Quarterly Biomass Stakeholders Meeting

The purpose of the state initiated Quarterly Biomass Stakeholder Meeting is to bring together various interests, organizations, and individuals throughout the state to discuss the current status of the Chariton Valley Biomass Project and explore possibilities for collaboration and future funding opportunities to accelerate activities in the biomass area. The meeting, facilitated by the Iowa Department of Natural Resource, was held on August 21, 1997, in Des Moines, Iowa. The agenda included:

Introduction and Opening	Roya Stanley
Project Status by Chariton Valley	Jim Cooper Ed Woolsey Marty Braster
USDA/NRCS	Lyle Asell
Iowa State University	Dr. Robert Brown Dr. Gerald Miller Alan Teel
RW Beck	Conrad Anderson
IES Utilities	Gary Walling
Leopold Center For Sustainable Agriculture	Dennis Keeney
Iowa Energy Center	Floyd Barwig Norm Olson
Iowa Dept. of Natural Resources	Sharon Tahtinen
Future Goals/Needs	
Possible Project Integration/Partnerships	
Other items	

DOE's Bioenergy Feedstock Development Program

On September 8-11, 1997, Mr. Teel and Mr. Woolsey traveled to Stillwater , Oklahoma to attend the "Subcontractors And Cooperators' Workshop". The program contained remarks and reports from the BFDP/ORNL, OSU/Ag Research, and DOE Fuels and Power. The BFDP folks from Oak Ridge and the USDA gave updates on their program as well as Oklahoma State University in Stillwater, Oklahoma and the Short Rotation Woody and Herbaceous Feedstock researchers from seven states were present. Mr. Teel presented as part of a panel, discussing communication issues in a scale-up project, especially with the

producer segment. The specific topic was "How to Involve Farmers in a Scale-up Project".

Many important points were addressed at the meeting. One point which seemed to stand out above the others was the need for joint project coordination between the DOE and the USDA. Both groups promised, at the conclusion of the meeting, to work more closely together in the future.

Mr. Sandy McLaughlin of ORNL presented very interesting carbon sequestration numbers. He is currently estimating annual carbon storage potential of switchgrass as high as 4 Mg/ha/yr. There are estimates that this carbon storage could last as long as 25-40 years. With Mr. Patrick Foody estimating the international market for carbon as high as $35 per ton, this combination could bring as much as an additional $70 per acre in return. This amount would greatly increase the chances of quick commercialization of switchgrass to energy. A field trip to visit a facility was coordinated at the end of the program. Many in the group traveled to Tulsa, Oklahoma to visit the PrimEnergy, Inc. gasifier. As part of the demonstration the gasifier was operated on Iowa switchgrass. The biogas was then sent to a diesel engine generator set. To our knowledge this is the first time that electrical energy has been produced from the gasification of switchgrass. We were able to obtain a copy of a video tape made during the demonstration.

The operators of the unit praised the burning characteristics of the switchgrass. The unit was not set up to handle the grass material. In order to feed the material, it was first chopped with a tub grinder to approximately two inches and loaded into large garbage bins, (approximately 8'X10'X25'). The chopped switchgrass was then loaded by a wheeled loader into the gasifier hopper bin.

While the market for this type of unit is currently in the waste fuel arena, given certain economic scenarios, a market may develop quickly for this unit operating on a closed-loop dedicated biomass feedstock. From our perspective a critical consideration for the economic feasibility of the system may be the return received from the steam production.

GEOGRAPHICAL INFORMATION SYSTEM

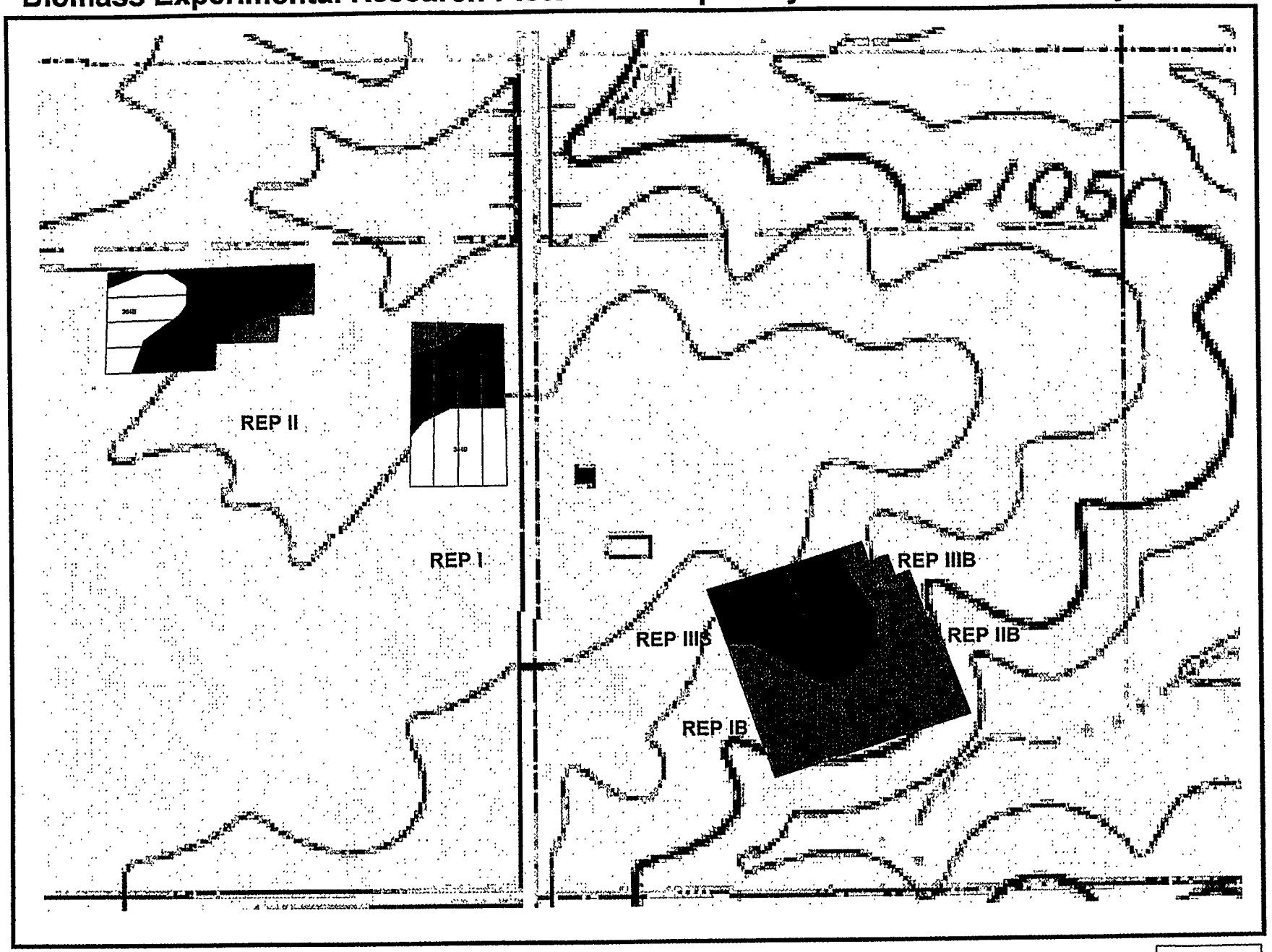
Third Quarter: Continued creation and maintenance of map layers and database for cooperating land owners. Maps include boundaries of fields that will be used to produce switchgrass for the project and a series of interpretations including soil mapping units, land capability classes, and yield potential. The accompanying database includes land owner name, field acres, field location, and soil mapping units and interpretations. These maps and database have been used to help plan and conduct specific research activities related to soil quality and water quality impacts of large scale biomass production and genetic improvement of switchgrass as a biomass crop. Maps and database have also been used to help plan the management and harvest of switchgrass plantings for use during the project.

Continued evaluation of soil mapping unit characteristics in the four -county project area for the purpose of identifying and grouping similar soils into "switchgrass management units." Soil characteristics being evaluated for the purpose of creating switchgrass management units include slope, landscape position, and capability class. Presently, like soil mapping units have been grouped into close to 70 potential switchgrass management units. Application of management units will facilitate assessment and recommendations related to productivity and environmental impact of large scale switchgrass plantings for biomass.

Fourth Quarter: Creation and maintenance of maps and database for field plots established as part of the fertility regime and genetic improvement research activities of the project. The project's global positioning system (GPS) and GIS capabilities have been used to create the maps and database. Maps consist of plot boundaries and interpretations including soil mapping units and land capability classes. The database includes plot sizes, plot locations, conditions prior to planned treatments, treatments applied to the plots, and measurements of treatment responses.

Creation of four-county project area and region wide maps and databases to assist with water quality, carbon sequestration, wildlife benefits, and harvest and handling aspects of the project. These maps include hydrologic units and water quality monitoring sites in the Rathbun Lake watershed. The interpretation of water quality models, water quality related research, and environmental benefits indices of conservation programs, such as the Conservation Reserve Program, are being used to create maps for the purposes of assessing and guiding project activities, including the establishment and management of switchgrass plantings.

Biomass Experimental Research Plots Land Capability Class -- Lucas County, Iowa



Source: Iowa State University Agronomy Department
Golden Hills Resource Conservation & Development
USGS Digital Raster Graphics
Iowa Cooperative Soil Survey

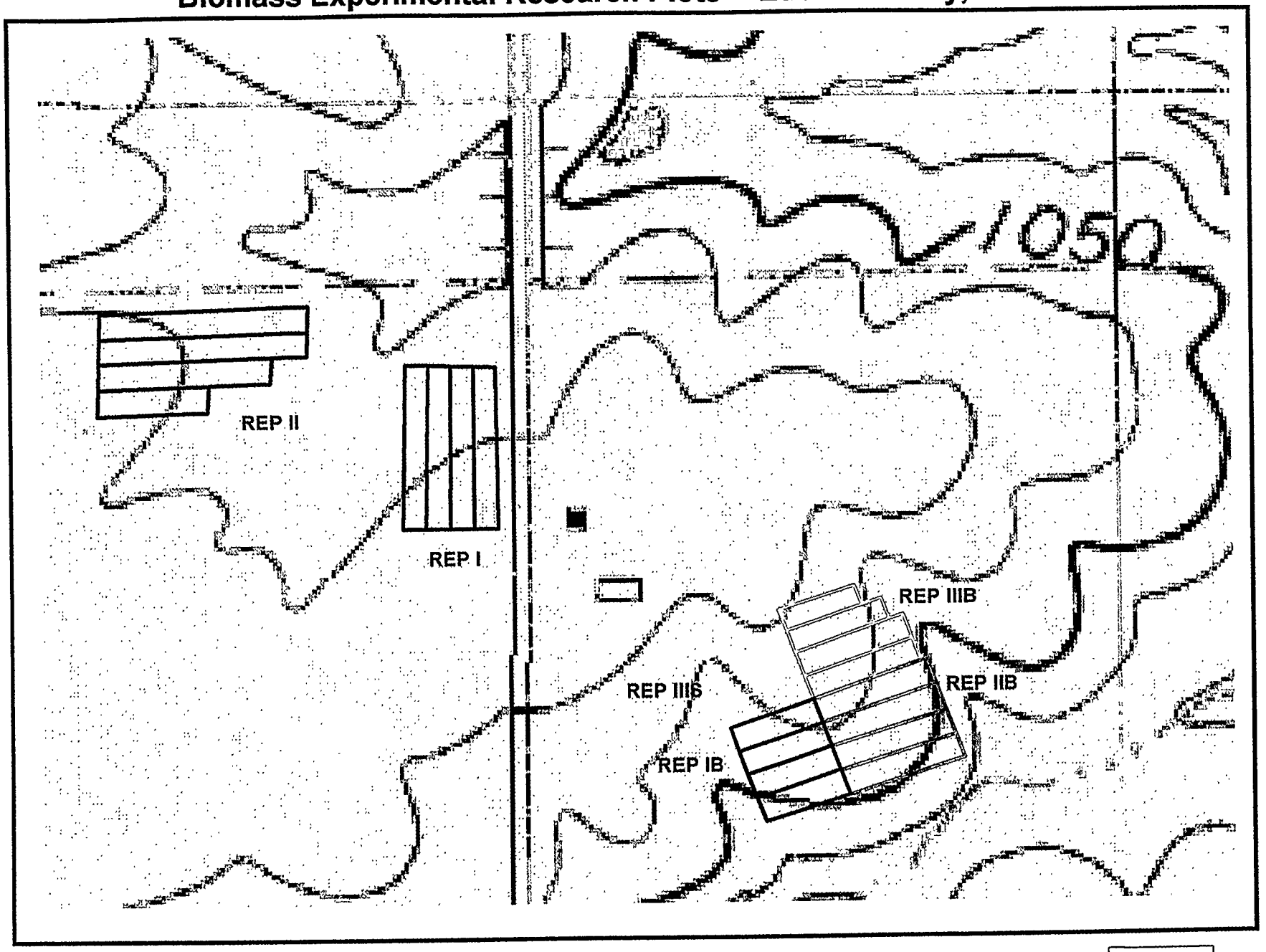
Soil Land Capability Class
2W
2E
3E
4W

100 0 100 Feet

N

LUCAS

Biomass Experimental Research Plots -- Lucas County, Iowa



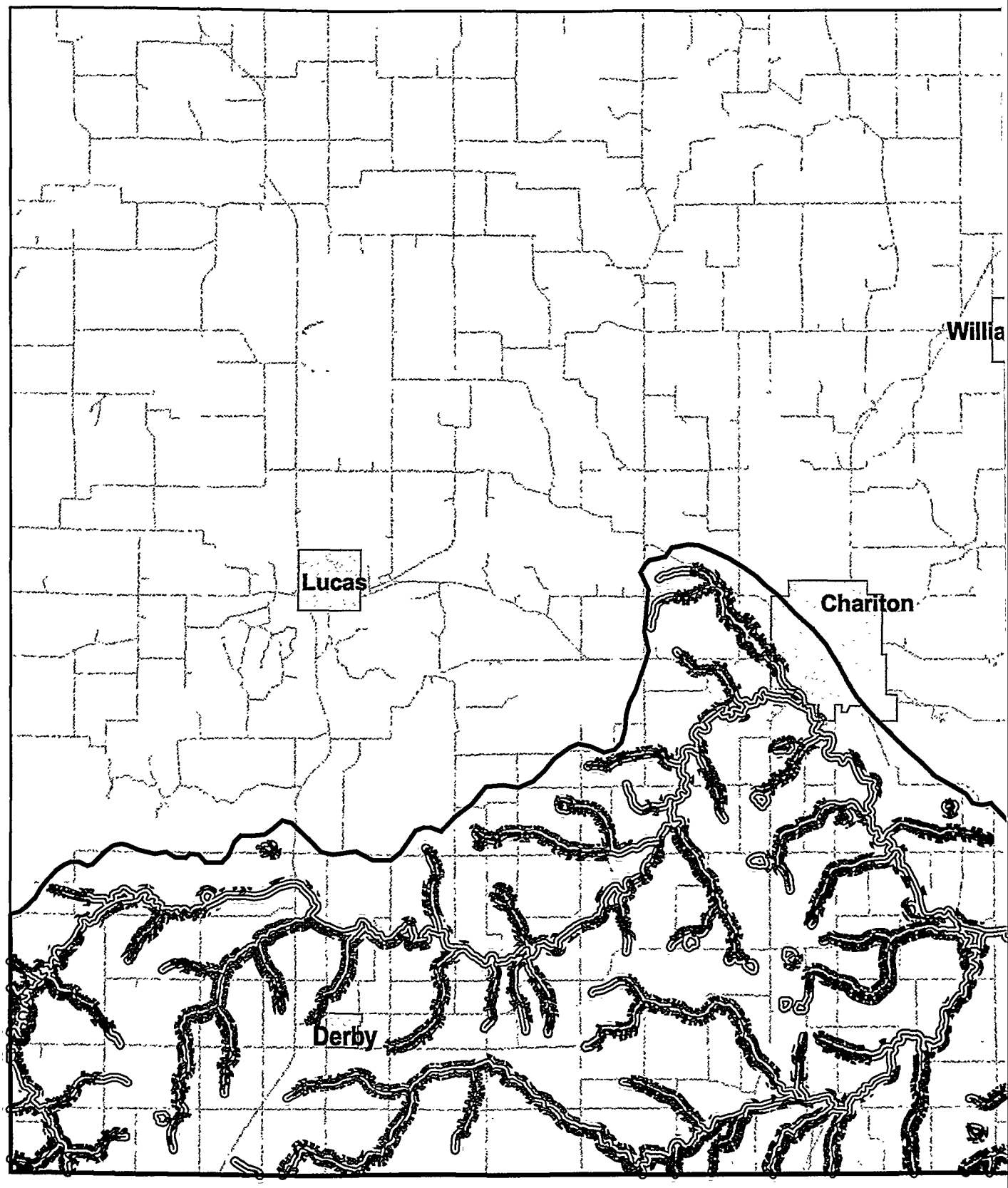
Source: Iowa State University Agronomy Department
Golden Hills Resource Conservation & Development
USGS Digital Raster Graphics

100 0 100 Feet

N

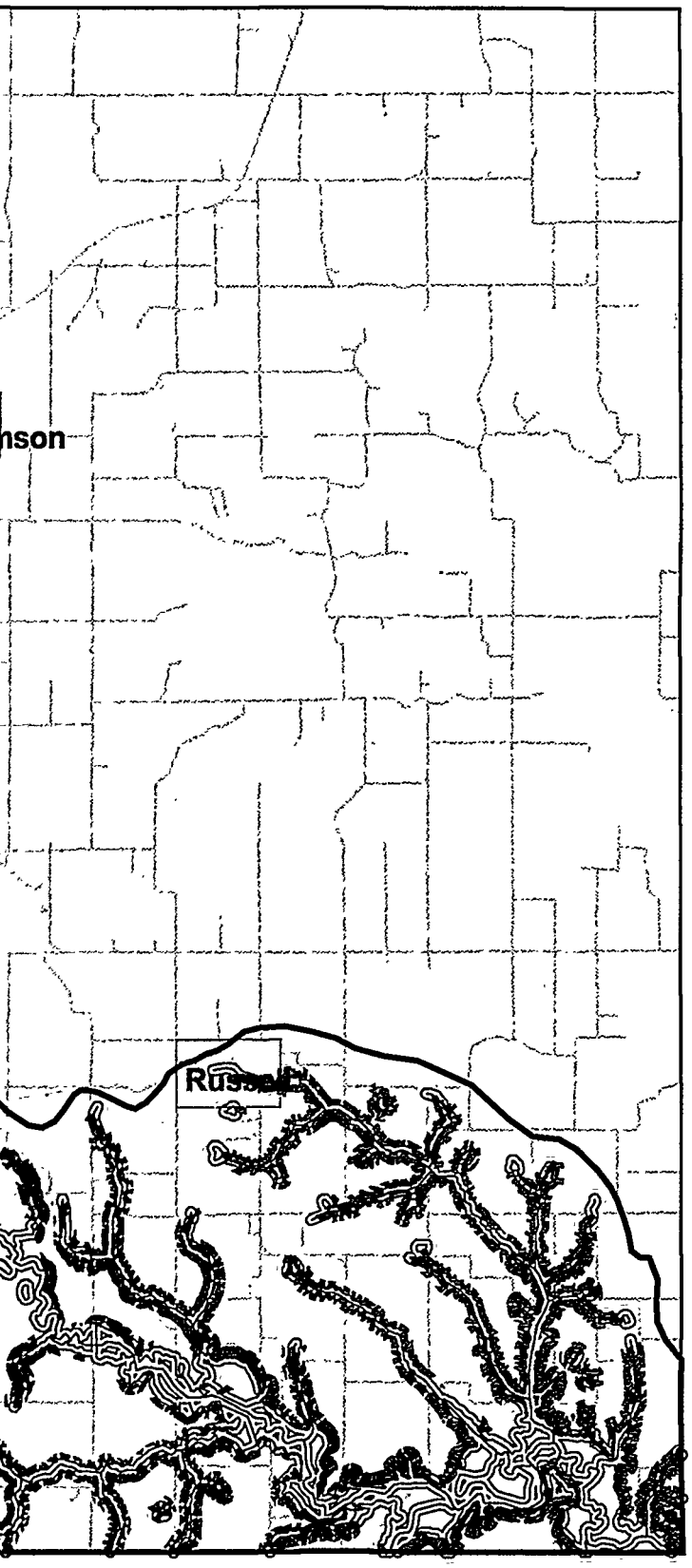
LUCAS

LUCAS COUNTY STREAM BUFFERS AND SI
SOIL SLOPE CLASSES -- RATHBUN LAKE W/



Source: Iowa Department of Natural Resources NRGIS
Chariton Valley RC&D
Iowa Cooperative Soil Survey
Golden Hills RC&D

LECTED
TERSHED

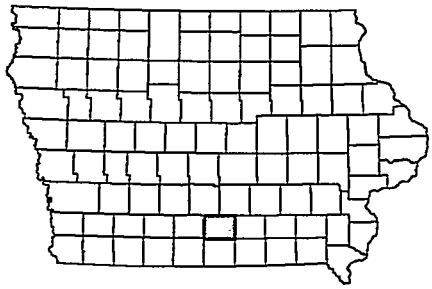


LEGEND

- Rathbun Lake Watershed Boundary
- Lucas County Drainage – Rathbun Lake Watershed
- Soils > 5% Slope Within 200 Meter Stream Boundary (11,040 Acres)
- 100 Meter Stream Buffer
- 200 Meter Stream Buffer
- City or Town
- Roads

N

1 0 1 2 Miles



Golden Hills Resource Conservation & Development, Oakland, Iowa

APPENDIX

ATTACHMENT 1

Preliminary Draft - Switchgrass Co-Firing Test Protocol

PRELIMINARY DRAFT - FOR REVIEW AND COMMENT ONLY

Chariton Valley Biomass Project

Switchgrass Co-Firing Test Protocol

Rev. 0: November 21, 1997

RW BECK

Chariton Valley Biomass Project
SWG Co-Firing Test Protocol
Table of Contents

Page

List of Exhibits

Chariton Valley Biomass Project

SWG Co-Firing Test Protocol

1. **Introduction:** IES Utilities ("IES") in conjunction with several other parties as described in item 4 below are scheduled to conduct a Switchgrass ("SWG") Co-Firing Test at the Ottumwa Generating Station (OGS), a 700 MW (nominal) pulverized coal-fired power plant near Ottumwa, Iowa. A Site Plan for the SWG Co-Firing Test is provided in Exhibit 1 attached. The plant is partially-owned and operated by IES Utilities and currently burns Powder River Basin ("PRB") Coal. IES intends to conduct the SWG Co-Firing Tests (the "Test") in April, 1998 just prior to OGS's scheduled annual plant shutdown in May. The Co-Firing Test Schedule is provided in Exhibit 2 attached.

2. **SWG Co-Firing Rate and Test Duration:** The duration of the Test is constrained by the amount of SWG that will be available, which is currently estimated to be approximately 3000 tons. The maximum design SWG co-firing rate is currently set at 10% of total fuel input on an energy basis which corresponds to approximately 50 tons/hr of SWG delivered at a moisture content of 12% by weight and a higher heating value of 7000 Btu/lb. Assuming SWG is co-fired at the four corners of the boiler, the maximum SWG co-firing rate at each of the four corner windboxes during commercial operation would be 12.5 tons/hr. The boiler at OGS is a double furnace design with no dividing wall between the furnaces. Thus, the maximum SWG co-firing rate is 25 tph per furnace.

   For the purpose of reducing the cost and prolonging the duration of the Test, SWG will be co-fired in only one of the two furnaces, i.e., at the two corners on one end of the boiler. Thus, the SWG co-firing rate for the Test will be 25 tons/hr and the Test Duration will be 120 hours (5 days).

3. **Test Objectives:**

3.1 Demonstrate that OGS, as modified to co-fire SWG, is capable of changing fuel firing from 100% coal-firing to 90% Coal/10% SWG-firing and back again to 100% coal-firing without significantly impacting net plant output or plant availability ("Bumpless transfer capability").

3.2 Demonstrate the modified windboxes are capable of firing up to 12.5 tph of SWG.

3.3 Demonstrate the pneumatic conveying system is capable of reliably transporting 12.5 tph of SWG from the outlet of the shredding process to the burner tip.

3.4 Examine the impact of varying SWG maximum size from 1.5 inches to 3.0 inches throughout the 120 hour Test on (a) unburned carbon content in the flyash and bottom ash, (b) on pneumatic conveying system reliability and (c) on stack emissions, e.g., opacity and NO_x.

3.5 Examine the impact of co-firing 25 tph of SWG in one of the two furnaces at OGS for 120 hours on boiler slagging and fouling rates.

3.6 Producer confidence
? How part. size adjusts unburned carbon

4. **Responsibilities of Each Participant**

- **IES (Owner/Operator):** To review and approve all aspects of the Test and to retain care, custody and control of OGS and all SWG co-firing facilities throughout the Test.

- **Chariton Valley RC&D (Project Developer):** To obtain DOE co-funding for the SWG Co-Firing Test and to coordinate and facilitate communication among the test participants.

- **ABB-CE (Boiler Manufacturer):** To conduct detailed analyses of the SWG and PRB coal and to design, fabricate, and install modifications to two corner windboxes.

- **Prairie Lands Cooperative (SWG Supplier):** To supply and deliver to OGS 3000 tons of SWG that meet the SWG Quality Spec (see Exhibit 5). Prairie Lands will subcontract out mowing, baling, loading, transporting, and off-loading at OGS.

- **R. W. Beck and ELSAMPROJEKT (Test Engineer):** To develop the co-firing test procedure, the co-firing system design, and the piping spec; to procure piping; to coordinate the performance of the test; and to analyze test results and prepare a Test Report.

A Co-Firing Task List and Cost Estimate is provided in Exhibit 3 attached.

5. **Windbox Modifications:** [Awaiting proposal by ABB-CE]

6. **SWG Co-Firing System Design:** The on-site SWG co-firing equipment and system design is illustrated in Exhibit 4. Tents will be used to cover SWG sizing and pneumatic conveying equipment. Tarps will be used to cover SWG stored on site. Portable fans will be used to control dust as required.

   Tractor driven, self-loading tub grinders will be used to convert large square bales into sized SWG (1.5" to 3.0" minus). Each tub grinder's maximum throughout will be _____ tph. We will use one tub grinder per windbox and have extra tractor/tub grinder on-site as a spare.

A rotary air lock valve will be used to provide a consistent SWG feed to the pneumatic conveying system. The method of providing the rotary valve a uniform feed from the tub grinder is still under investigation.

7. **Sampling and Measurement during Test:**

   a) Batch samples every eight hours - 15 samples total

      - SWG moisture content and HHV (with hand-held probe)
      - SWG maximum size
      - bottom ash
      - flyash

   b) Continuous monitoring and measuring

      - SWG feed rate (weigh every bale?)
      - Stack-emissions: Opacity and NO_x with OGS is continuous emissions monitor (CEM)
      - OGS plant output and availability

8. **SWG Procurement Plan [Later by Prairie Lands]**

   To be considered acceptable fuel for the purpose of this Test each SWG bale delivered to OGS must meet the SWG Quality Spec provided in Exhibit 5. Supply and procurement activities include:

   - mowing
   - baling
   - loading onto trailer
   - transporting to OGS
   - off-loading at OGS
   - cover with tarps
   - coordination of all SWG procurement contractors

9. **SWG and Coal Analyses:** Fuel analyses will be performed by ABB-CE on one (1) coal sample and four (4) switchgrass samples:

- Powder River Basin (PRB) coal
- Pre-frost switchgrass (washed)
- Pre-frost switchgrass (unwashed)
- Post-frost switchgrass (washed)
- Post-frost switchgrass (unwashed)

Standard ASTM analyses performed for both switchgrass and coal will consist of:

- Proximate Analysis
- Ultimate Analysis
- Higher Heating Value
- Ash Fusion Temperatures (4-point, reducing atmosphere)
- Ash Composition
- Chlorine Content

In addition, ash fusion temperature analyses will be performed on a total of six (6) blends of coal and switchgrass samples. Blends will consist of the coal and each of the two switchgrass samples representing the extremes of ash fusion temperatures. Blends will be selected to match and bracket the proposed co-firing rate and fuel addition strategy.

Coal and switchgrass mineralogy will be further explored through computer-controlled scanning electron microscope (CCSEM) analysis, which will provide quantitative information on the discrete mineral particles within the coal and biomass samples. This data adds insight on the identity, form, and size distribution of the included and excluded minerals within the fuels, which in turn can be interpreted to indicate slagging and fouling tendencies.

The subject fuels will be compared with those in the ABB data base to provide additional insight into expected performance in terms of fuel handling, ash

deposition and ESP ash collection characteristics. CCSEM analyses will be performed on the two (2) unwashed switchgrass samples.

10. Test Methodology

- **Day 1 (Hrs: 1-24):** Stabilize Operation @ 1.5" minus SWG
  Start-Up Corner #1
  Start-Up Corner #2

- **Day 2 (Hrs: 25-48): Bumpless Transfer Test @ 1.5" minus SWG**
  Shutdown and restart SWG Co-firing three times

- **Day 3 (Hrs: 49-72):** Operate @ 2.0" minus SWG

- **Day 4 (Hrs: 73-96):** Operate @ 2.5" minus SWG

- **Day 5(Hrs: 97-120):** Operate @ 3.0" minus SWG

11. **Internal Boiler Inspection after Test during Annual Plant Shutdown:**

- Slagging on furnace waterwalls and pendant Superheater
- Fouling on superheater and reheater surface

12. **Ash Analyses (primarily for unburned combustibles):**

- Flyash
- Bottom ash
  - furnace
  - economizer
  - air preheater

13. Test Safety Program

- Use portable fans for dust control

- Adopt standard OGS Safety Program (each test participant must provide written verification that he will follow this program).
- Supplement OGS Safety Program as required following OSHA procedures, e.g., need for a self-contained breathing apparatus.

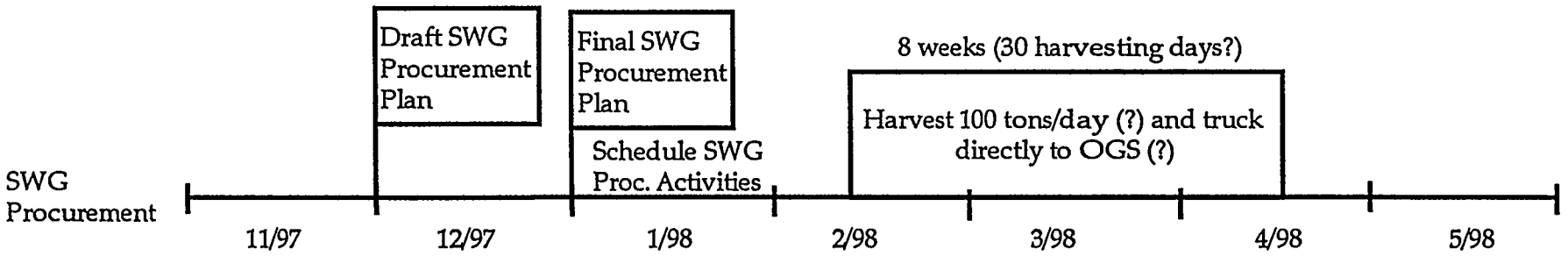
Chariton Valley Biomass Project
Exhibit 1: Site Plan for SWG Co-Firing Test

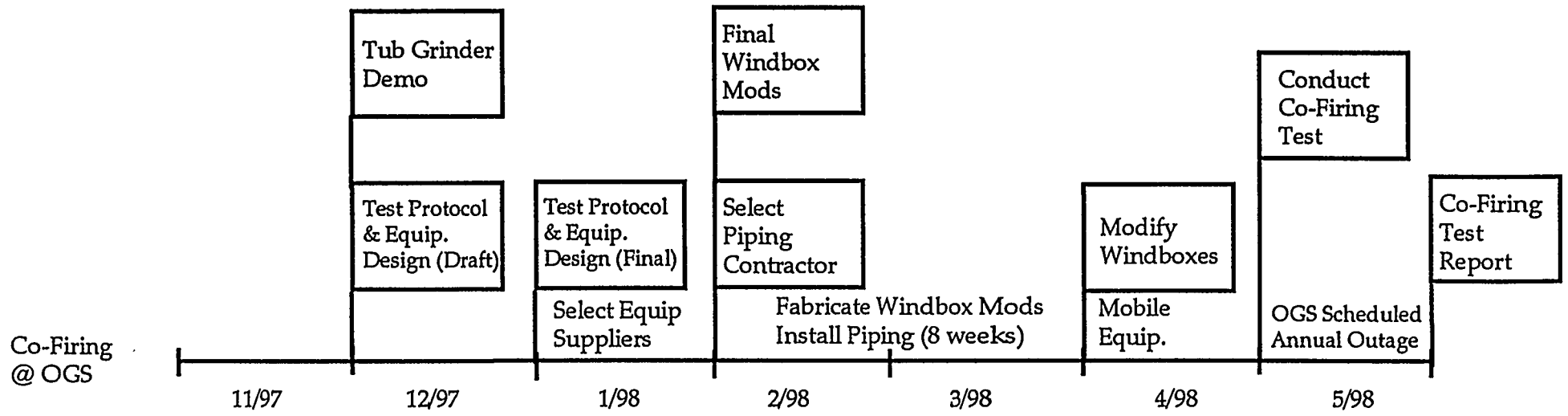
[Later - awaiting Site Walk Down by R. W. Beck]

R·W·BECK

Chariton\swgsp.ppt

Chariton Valley Biomass Project
Exhibit 2: SWG Co-Firing Test Schedule





R·W·BECK

chariton\swgcof.ppt

Chariton Valley Biomass Project
Exhibit 3: SWG Co-Firing Task List and Cost Estimate

Co-Firing Tasks	CVRC&D	ISU Extension	Prairie Lands	IES Utilities	R. W. Beck	Contractors	TOTAL
1. Develop Test Plan	--	--	--		$13,000	$18,700[1]	
2. Design SWG On-Site Facilities	--	--	--		15,000	7800[1]	
3. Prepare equip & piping specs	--	--	--		12,000	--	
4. Select equip & piping contractors	--	--	--		10,000	--	
5. Conduct coal & SWG analyses	--		--		--	17,900[2]	
6. Design, fabricate, and install windbox modifications	--	--	--		--	[2]	
7. Fabricate & install piping	--	--	--	--	--	[3]	
8. Supply & operate temp equip	--	--	--	--	--	[4]	
SWG Procurement Tasks							
9. Develop SWG Procurement Plan				--	--	--	
10. Identify equip & labor reqts				--	--	--	
11. Schedule harvest & transport				--	--	--	
12. Mow SWG (equip & labor)				--	--	[5]	
13. Bale SWG (equip & labor)				--	--	[6]	
14. Transport SWG to power plant				--	--	[7]	
15. Off-Load SWG at power plant					--	[8]	

R·W·BECK

Chariton Valley Biomass Project
Exhibit 3: SWG Co-Firing Task List and Cost Estimate

	CVRC&D	ISU Extension	Prairie Lands	IES Utilities	R. W. Beck	Contractors	TOTAL
120-Hour Co-Firing Test							
16. Conduct Test					12,000	$11,500[1] [4]	--
17. Analyze ash samples							
18. Inspect boiler (slagging & fouling)							
19. Analyze data & Prepare Test Report	____	____	____	____	10,000	$15,600[1]	--
TOTAL COST					$72,000		
Test Contingency Fund[9]							

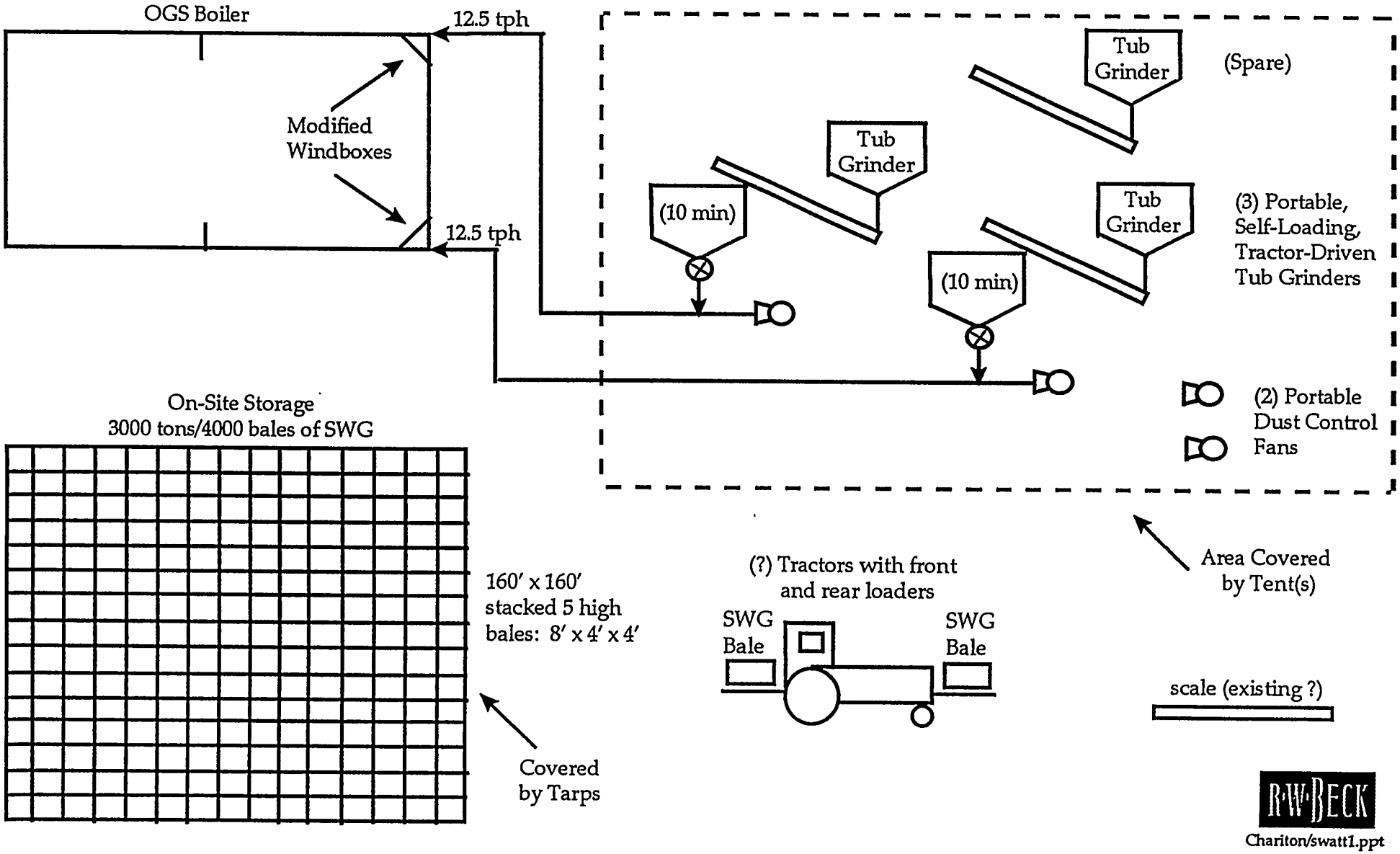
Notes:

1. ELSAMPROJEKT A/S may participate in the actual test and review and comment on the Test Plan and on the design of the SWG handling facilities to be developed by R. W. Beck. [Note: Their participation depends on resolving current scope and cost issues.]
2. ABB/CE will conduct fuel analyses and design, fabricate, and install all windbox modifications.
3. _____ will supply and erect all piping, valves, etc.
4. _____ will supply and operate all tub grinders; _____ will supply blower(s); _____ will supply tents.
5. _____ will mow _____ acres of SWG.
6. _____ will bale _____ acres of SWG.
7. _____ will load and transport 3000 tons (approximately) of SWG to OGS.
8. _____ will off-load and stack 3000 tons (approximately) of SWG at OGS
9. Funding required to cover additional costs if test needs to be postponed, extended, or redone.

R·W·BECK

ca\chariton\swgtbl.doc

Chariton Valley Biomass Project
Exhibit 4: SWG Co-Firing System Design



R·W·BECK

Chariton/swatt1.ppt

Chariton Valley Biomass Project
Exhibit 5: SWG Quality Specifications

1. Maximum moisture content: 15% by weight

2. Minimum higher heating value: 6500 Btu/lb

3. Maximum inorganic/trash content: 1% by weight

4. Negligible rotten material and wet spots

5. All SWG will be delivered in "large square bales" with approximate dimensions: 4' x 4' x 8'

ATTACHMENT 2

ELSAMPROJEKT

ELSAMPROJEKT

R. W. Beck
555 D'Onofrio Drive
Suite 103
Madison, WI 53719-2053
United States

Att.: Mr C. Anderson

Date : November 17, 1997
Letter no. : EP-3007
Ref. : EP 11148
JCC/dth
Direct tel. : +457923 3320
Direct E-mail : jcc@elsamprojekt.dk

Re: Proposal for Assistance to R.W. Beck.

Dear Mr Anderson

With reference to your letter dated October 31, 1997 and the enclosed proposal for a subconsultancy agreement, we have the pleasure of submitting a proposal for technical assistance to R.W. Beck for their Chariton Valley project.

This proposal is jointly proposed by ELSAMPROJEKT and I/S MIDTKRAFT with ELSAMPROJEKT as the lead party.

1. Scope of Services.

The scope of services are specified in the enclosed specification of services with reference to the before-mentioned subconsultancy agreement.

2. Time Schedule.

We offer to perform the above-mentioned services in accordance with the time schedule, specified in the subconsultancy agreement. It is assumed that task 4 and 5 will be finished during 1998.

3. Price.

The above-mentioned scope of services, including travel and accommodation expenses, is offered at a total price of:

79,600.- USD

This price is based on the currency exchange ratio between USD and DKK (6.50 DKK/USD).

The costs of the individual tasks are as follows:

Task 1	:	18,700 USD
Task 2	:	5,200 USD
Task 3	:	11,500 USD
Task 4	:	26,000 USD
Task 5	:	15,600 USD

Additional services agreed upon will be billed at a standard rate of 85 USD/hour. Costs of travelling, accommodation and allowances according to actual documented costs incurred during additional services will be charged to the Client plus a 5% handling fee.

All prices are exclusive of VAT, duties or taxes.

4. Validity of the Proposal.

This proposal is valid until the December 31, 1997.

5. General Conditions.

This proposal is based on the "ABR 89 - General Conditions for Consultancy Services", as prepared by a committee of technical experts appointed by Danish consultancy companies in conjunction with a technical committee under the Danish Ministry of Housing and Building.

The liability of the Consultant is limited to the amount recoverable under the Consultant's Professional Insurance Policy with a maximum equal to the total price of the services.

6. Payments.

Our proposal is based on a payment schedule with monthly payments according to the actual costs and expenses during the previous month up to the level specified.

This project is handled by J. Clausen who will be of assistance to you in case you have questions to our proposal.

We hope the proposal is according to your expectations, and we look forward to receiving your evaluation.

Yours sincerely
ELSAMPROJEKT A/S

Jens Clausen / Anders D. Boisen

Encl.: As mentioned above.
CC: JRC, I. Rasmussen, MK

Date : November 17, 1997
Init : JCC/dth
Ref. : EP 11148

Specification of Services

Client : R. W. Beck
Project : Chariton Valley

1. Introduction.

Reference is made to the proposed subconsultancy agreement dated October 31, 1997. The services that the Client - R.W. Beck - has suggested to subcontract from the subconsultant (ELSAMPROJEKT) are described. In this specification some details are provided for each of the services. Additionally some further services which are considered beneficial to the Client are offered.

The services are provided by a partnership of ELSAMPROJEKT and I/S Midtkraft. Midtkraft is a member of the ELSAM Power Pool and Midtkraft has been the leading party of the co-firing of straw development in Denmark and has built and is operating the straw co-firing system of the 150 MW_e Studstrup Unit 1.

The tasks specified by the Client are:

Task 1 Review the 60-hour performance test programme.

Task 2 Review the temporary straw handling and processing plant for the 60 hour performance test. We have included a review of the co-firing system including burner and straw injection systems.

Task 3 Provision of a senior test engineer to participate in the 60 hour performance test.

Task 4 Review the permanent straw handling and processing equipment.

Additionally, the subconsultant proposes:

Task 5 Assistance in evaluation of the test results.

Assistance in evaluation of the test results and comparison of those with the our test results. This way the value of the Clients test result can be greatly enhanced.

2. Scope of Services for Task 1.

The services specified in the proposed subconsultancy agreement are provided.

Further this task will also include:

- Visit to Denmark including visit to MKS co-firing installation, meeting with straw transport company, straw suppliers, straw procurement of ELSAM and EP and MK specialists. The visit in Denmark is assumed to last 4 - 5 days.

- Review and provide written comments to 60-hour-test programme including advice on sampling, analysis procedures, characterization of fuel, emission measurements, by product properties and fouling behaviour. This way the Client will benefit from the experience gained by ELSAM through its +50 million USD biomass development programme.

A total of 185 hours is spent on this task. The costs are 18,700 USD.

3. Scope of Services for Task 2.

A total of 75 hours has been assumed for this task. Total costs are 7,800 USD.

4. Scope of Services for Task 3.

It is assumed that a total of 7 days is spent in the US. The number of hours spent on the task is 80. One trip to the US is included. Total costs are 11,500 USD.

5. Scope of Services for Task 4.

A total of 225 hours is spent on the job. A 3-day-project meeting at the Client's premises has been included. One trip to the US is included. Total costs are 26,000 USD.

6. Scope of Services for Task 5.

The aim of this additional task is to apply the knowledge from ELSAM's long-term co-combustion tests to improve the interpretation of the 60-hour-test results. Especially combustion behaviour, emissions, ash contamination and slagging and fouling behaviour are difficult to evaluate on the basis of short-term tests, but if sufficient chemical data are provided from the test results, the subconsultant will be able to advise on long-term effects.

A total of 140 hours is spent on the task. A 3-day-trip to the US has been included. Total costs are 15,600 USD.

7. Total Costs.

The accumulated costs for the 5 tasks are 79,600 USD. A total of 705 hours is spent on the tasks and 3 trips on economy class to Wisconsin are included.

8. Resources Usage.

The subconsultant will appoint a project manager who will be in charge of our activities and have the contact to the Client.

The subconsultant will spend the specified number of hours on the tasks. We consider the number reasonable in order to provide the specified services. We will report hours spent on each tasks on a monthly basis in order to allow the Client's project manager follow up on our activities. The Clients and our project manager will work closely together to plan the work of the subconsultant for the maximum benefit of the Client.

9. CVs of Assigned Project Members.

The CVs of the following members of the staff who will be involved in the services are attached:

Niels Kirkegård
Position in project: Project manager and mechanical engineer

Bo Sander and Peter F. Binderup Hansen (MK):
Position in project: Responsible for test procedures and chemistry

Peter Overgård (MK):
Position in project: Mechancial engineering systems review and participation in the 60-hour-test programme

10. References.

A specification is included describing the biomass development activities of ELSAM. This gives an impressive overview of the activities carried out over the last 10 years.

We are convinced that no other entity has the same broad and deep experience in using straw on a large scale in the energy sector.

ATTACHMENT 3

Switchgrass Production in Iowa: Economic Analysis, Soil Suitability, and Varietal Performance

Switchgrass Production in Iowa:

Economic Analysis, Soil Suitability, and Varietal Performance

Proposal submitted to

Lockheed Martin Energy Systems, Inc.

in response to RFP No. SY510-90

Submitted by

Chariton Valley Resource Conservation and Development, Inc.

RR#3, Box 116A

Centerville, Iowa 52544

515-437-4376

cvrcd@se-iowa.net

Principal Investigator - James Cooper

Switchgrass Production in Iowa:
Economic Analysis, Soil Suitability, and Varietal Performance
Technical Proposal

Introduction

The research activities described in this proposal directly support, enhance, and complement the US Department of Energy's (DOE) Biomass Power for Rural Development project currently underway in cooperation with Chariton Valley Resource Conservation and Development (RC&D), Inc. in southern Iowa. This research will provide information necessary to support the analysis and development of switchgrass as a biofuel feedstock for electric power generating technology. Activities in this proposal will build on and enhance research conducted on switchgrass in the plain states that has been supported by the Biofuels Feedstock Development Program (BFDP) for more than five years. It complements the Biomass Power for Rural Development project by integrating economics and agronomic research. The results of this research will provide guidance to producers who are integrating switchgrass as an energy crop into their farming systems on more than 4,000 acres of Conservation Reserve Program (CRP) land in a four-county area of southern Iowa. The project also begins an improvement program designed to develop the potential of reed canarygrass as a major bioenergy crop in southern Iowa. Chariton Valley RC&D, Inc. will accomplish the research described in this proposal in close cooperation with the Departments of Agronomy and Economics at Iowa State University (ISU).

Research Tasks

I. Determine the economic potential of switchgrass as an agronomic crop for bioenergy:

A. There is a need to document on-farm costs and resource commitments of producing switchgrass as a energy crop. A major goal of this task will be to understand the profitability of producing switchgrass for bioenergy relative to existing and alternative land uses. Production costs, technology development, acceptance by farmers, scale of production, and existence or development of a market all relate to profitability. Whole-farm budgets will be developed from as many as 6 case study farms in the Chariton Valley area. The results of this task will be used to prepare a draft agricultural extension bulletin detailing switchgrass production budgets, machinery complements, and labor and time costs.

B. There will be significant regional economic impacts as a result of planting 4,000 or more acres of switchgrass as a bioenergy crop in southern Iowa. Land currently in CRP is likely to be converted to switchgrass production first, followed by marginal cropland and pasture. The Iowa Economic/Fiscal Impact modeling System (IE/FIMS) will be used to identify and quantify city and county economic, employment, labor force, population, and fiscal

impacts in response to changes in local or regional economies that result from large scale conversion of land to switchgrass production for bioenergy. The result of this task will be an agricultural extension publication describing the model assumptions, parameterization, and sensitivity of the impact estimates to changes in the assumptions.

C. On-farm energy consumption for machinery operation and inputs to produce switchgrass as a bioenergy crop have not been quantified. These energy expenditures will be compared to those associated with alternative land uses. Energy in terms of output will be evaluated in other parts of the Chariton Valley project. A major literature review will provide the basis for any background information that exists. The results of this task will either be incorporated into the previously mentioned extension bulletins or be used to prepare a draft agricultural extension bulletin itemizing energy budgets for switchgrass production as a bioenergy crop for electric power.

II. Determine the effect of soil variability and environmental quality on switchgrass production:

A. There is significant variability in soil quality and expected yields on land in the Chariton Valley area that will be used to produce switchgrass. Higher quality soils in the north give way to thinner, less productive soils in the south. Predicting yield levels and the response of these soils to fertilizer application will be important to advising farmers on switchgrass management to optimize productivity and economic gain. This task will evaluate and predict yield variability across the region using a regression-based sampling scheme designed to evaluate both baseline yields and the potential improvement to be gained with three levels of fertilizer application relative to indicators of soil quality. These indicators will include soil texture, chemistry, water holding capacity, and organic matter content.

B. An important benefit anticipated from switchgrass production, improved soil quality, will be evaluated by monitoring rates of soil erosion, runoff characteristics, and soil tilth on subplots within the switchgrass production fields. Contrasts between switchgrass fields and nearby fields in alternative land uses will be used to estimate induced changes in soil quality associated with switchgrass production.

C. This task will expand planned soil research to quantify the accumulation of soil carbon in energy crop fields. Based on preliminary data, switchgrass production will have a profound effect on increasing stored carbon, reversing the effects of past crop production. The carbon levels in switchgrass fields of known age will be compared to adjacent row crop and pasture fields. The effect of harvesting the grass on the root system and level of sequestered carbon will be determined. Comparisons of similar soil types under different land uses, levels of management, and of long established switchgrass stands to new stands established as part of the project will give a range of carbon benefits associated with the conversion of traditional crop lands to energy crops.

III. Evaluate and develop switchgrass and reed canarygrass germ plasm for bioenergy production and adaptation to Iowa:

A. To maximize yields and economic return to farmers, it will be important to select switchgrass varieties that are best suited to the soils and climate of the Chariton Valley area. This task will involve testing the performance of up to 20 existing cultivars and additional developmental lines to evaluate comparative yields and biofuel traits. The results of this task will be used to make varietal recommendations for soils in the Chariton Valley area.

B. Reed canarygrass is a native cool-season grass widely adapted throughout the upper Midwest. Reed canarygrass produces high yields but germ plasm has not been widely evaluated or bred for biomass production. No reed canarygrass breeding for biomass is currently being conducted in the United States. In fact, virtually no research has been completed that even assesses the germ plasm base for forage traits that may also be of interest for biomass production. This task will evaluate the yield and biofuel characteristics of available reed canarygrass cultivars to make variety recommendations and to identify their limitations for bioenergy. This task will also produce a literature review summarizing existing genetic, agronomic, and environmental information about reed canarygrass production and development. Concurrently, this task will begin assessing the USDA Plant Introduction collection of reed canarygrass germ plasm as a first step toward developing improved cultivars for bioenergy production.

A Summary of Deliverables

I. QUARTERLY REPORTS: A one to two-page report briefly describing research activities and progress during each quarter will be submitted. Quarterly reports will be submitted by April 1, July 1, and October 1.

II. ANNUAL PROGRESS REPORTS: An annual report will be prepared and submitted prior to January 1.

III. FINAL REPORT: Three copies of the draft final report will be submitted for review and comment 30 days prior to the end-date of the contract. Upon approval, a reproducible (camera-ready) master and two copies of the final report will be submitted. The final report will document all research conducted during the period of funding and summarize and interpret the results.

IV. SUBCONTRACTORS' MEETING: A representative of Chariton Valley RC&D, Inc. will attend the annual subcontractors' meeting. If requested, a written and/or oral presentation describing research activities will be prepared for this meeting.

V. RECORDS of DATA and ACTIVITIES: Notebooks, records, and raw data related to the research shall be maintained in a retrievable form for a minimum of five years and will be made available upon request.

VI. QUALITY ASSURANCE AND ENVIRONMENTAL PROTECTION: If requested, compliance with requirements of the BFDP in the following areas will be demonstrated: All instruments used in this research project will receive manufacturers' recommended maintenance and periodic calibration checks according to referenceable techniques and methods. Consideration will be given to the possible impacts of field trials on environmental quality and steps will be taken to avoid or minimize any adverse impacts.

VII. MONTHLY COST ESTIMATE PLAN: A time-phased monthly cost estimate plan for the period of performance will be furnished with the subcontract proposal and revised (if necessary) within fifteen (15) days of the subcontract award. This plan will be updated fifteen (15) days after receipt of any modification increasing or decreasing the estimated cost of the subcontract or as deemed appropriate. The plan be provided via electronic mail to the following address: downingme@ornl.gov.

This proposal is firm for a period of not less than 180 calendar days after the closing date for receipt of proposals.

Offeror: Chariton Valley RC&D, Inc.

By: Leon Kaufdrich

Title: Treasurer

Date: 9/9/97

Solicitation No. SY510-90

ATTACHMENT 4

Cooperative Agreement With ISU

COOPERATIVE AGREEMENT
Between
CHARITON VALLEY RESOURCE CONSERVATION AND DEVELOPMENT, INC.
And
AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION
IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY

I. **This Agreement** by and between Chariton Valley Resource Conservation and Development, Inc. (hereinafter referred to as RC&D) and the Agriculture and Home Economics Experiment Station, Iowa State University of Science and Technology (hereinafter referred to as ISU) shall be in full force and effect on and after the date of its final execution. The RC&D is a non-profit corporation, governed by a board of directors appointed by local units of government, State of Iowa, as provided for in the Iowa Code Chapter 504A.

II. **Purpose:** The RC&D and ISU have a shared interest in developing the biomass industry in Iowa. To that end, this agreement defines the terms of cooperation between the RC&D and ISU to conduct research activities for the Biomass Power for Rural Development Project underway in southern Iowa.

III. **Therefore,** the RC&D and ISU deem it mutually advantageous to cooperate as follows:

A. The RC&D agrees to:

1. Reimburse ISU in an amount not to exceed $89,688 for expenses incurred in completing the activities and products described in Section III. B. Reimbursement shall consist of $51,388 for the period extending from the date of final execution of this agreement through September 30, 1998 and $38,300 for the period of October 1, 1998 through September 29, 1999. Reimbursement will be made in response to periodic billings submitted by ISU.

2. Participate in the planning and review of activities and products described in Section III. B. and to help provide or arrange for assistance and support as needed and requested by ISU in fulfilling the terms of this agreement.

B. ISU agrees to complete the research tasks described in B.1., B.2., B.3., and B.4. below. Completion of the tasks and products described herein are not assignable without the prior written consent of the RC&D:

1. Determine the effect of soil variability and environmental quality on switchgrass production:

a. There is significant variability in soil quality and expected yields on land in the Chariton Valley area that will be used to produce switchgrass. Higher quality soils in the north give way to thinner, less productive soils in the south. Predicting yield levels and the response of these soils to fertilizer application will be important to advising farmers on switchgrass management to optimize productivity and economic gain. This task will evaluate and predict yield variability across the region using a regression-based sampling scheme designed to evaluate both baseline yields and the potential improvement to be gained with three levels of fertilizer application relative to indicators of soil quality. These indicators will include soil texture, chemistry, water holding capacity, and organic matter content.

b. An important benefit anticipated from switchgrass production, improved soil quality, will be evaluated by monitoring rates of soil erosion, runoff characteristics, and soil tilth on subplots within the switchgrass production fields. Contrasts between switchgrass fields and nearby fields in alternative land uses will be used to estimate induced changes in soil quality associated with switchgrass production.

c. This task will expand planned soil research to quantify the accumulation of soil carbon in energy crop fields. Based on preliminary data, switchgrass production will have a profound effect on increasing stored carbon, reversing the effects of past crop production. The carbon levels in switchgrass fields of known age will be compared to adjacent row crop and pasture fields. The effect of harvesting the grass on the root system and level of sequestered carbon will be determined. Comparisons of similar soil types under different land uses, levels of management, and of long established switchgrass stands to new stands established as part of the project will give a range of carbon benefits associated with the conversion of traditional crop lands to energy crops.

2. Evaluate and develop switchgrass and reed canarygrass germ plasm for bioenergy production, biofuel characteristics, and adaptation to Iowa:

a. To maximize yields and economic return to farmers, it will be important to select switchgrass varieties that are best suited to the soils and climate of the Chariton Valley area. This task will involve testing the performance of up to 20 existing cultivars and additional developmental lines to evaluate comparative yields and biofuel traits. The results of this task will be used to make varietal recommendations for soils in the Chariton Valley area.

b. Reed canarygrass is a native cool-season grass widely adapted throughout the upper Midwest. Reed canarygrass produces high yields but germ plasm has not been widely evaluated or bred for biomass production. No reed canarygrass breeding for biomass is currently being conducted in the United States. In fact, virtually no research has been completed that even assesses the germ plasm base for forage traits that may also be of interest for biomass production. This task will evaluate the yield and biofuel characteristics of available reed canarygrass cultivars to make variety recommendations and to identify their limitations for bioenergy. This task will also produce a literature review summarizing existing genetic, agronomic, and environmental information about reed canarygrass production and development. Concurrently, this task will begin assessing the USDA Plant Introduction collection of reed canarygrass germ plasm as a first step toward developing improved cultivars for bioenergy production.

3. Determine the effects of timing of harvest on burning qualities:

a. Little research has been conducted on the burning of switchgrass. Genotype variability will be assessed for two sampling periods, fall and spring. Other switchgrass stands of the cultivar "Cave-In-Rock" are available at several Iowa locations to allow more sampling periods. The optimum time of harvest for biofuel and whether storing switchgrass over winter in the field has a positive or negative effect, are unknown. In addition to optimizing harvest time for burning, harvest also will have an effect on recycling nutrients in the field. Nitrogen concentrated in the leaves will likely be lost to the field if harvest occurs before leaf drop and may not be useful from a burning perspective. Letting some leaf loss occur may improve both burning and nutrient cycling. This task will give some clues on the best harvest management.

Two stands of switchgrass at different locations will be evaluated for burning characteristics at six time points from fall 1997 through spring 1998. Whole plant samples will be separated into leaf and stem fraction, and tests conducted on the whole plant and each fraction independently. Analyses of burning traits will be conducted on this material. The change-over time will be tracked during the six sampling dates.

4. Prepare and submit monthly reports to the RC&D by the 15th of each month following the report month, an annual report on or about September 30, 1998, and a final report prior to September 29, 1999 that describe activities and findings related to completing the research tasks identified in III. B. Reports will include an accounting of any ISU in-kind contributions.

C. It is mutually agreed:

1. Completion Date: This agreement will remain in full force and effect from the date of its final execution through September 29, 1999. This agreement may be affirmatively renewed with the written consent of both the RC&D and ISU.

2. Intent to Cooperate: It is the intent of the RC&D and ISU to fulfill their obligations under this agreement. However, neither the RC&D or ISU shall be obligated beyond funds available.

3. Modification: This agreement may be modified by an amendment duly executed by authorized officials of both the RC&D and ISU.

4. Indirect Costs: No indirect costs are allowable under this agreement.

5. Termination: In the event that circumstances prohibit ISU or the RC&D from fulfilling the terms and conditions of this agreement, the RC&D may, at its discretion, declare this agreement null and void by providing ISU with 15 days advance notice in writing of such a decision. Upon giving of such notice, this agreement shall be rendered null and void and of no further force and effect.

6. Records of Data and Activities: Notebooks, records, and raw data related to the research shall be maintained in a retrievable form for a minimum of five years and will be made available upon request.

7. Quality Assurance and Environmental Protection: All instruments used in this research project will receive manufacturers' recommended maintenance and periodic calibration checks according to referenceable techniques and methods. Consideration will be given to the possible impacts of field trials on environmental quality and steps will be taken to avoid or minimize any adverse impacts.

8. Civil Rights Act: The activities conducted under this agreement shall be in compliance with the nondiscrimination provisions contained in the Titles VI and VII of the Civil Rights Act of 1964, as amended; the Civil Rights Restoration Act of 1987 (Public Law 100-259); and other nondiscrimination statutes: namely, Section 504 of the Rehabilitation Act of 1973, Title IX of the Education Amendments of 1972, and the Age Discrimination Act of 1975. They will also be in accordance with regulations of the Secretary of Agriculture (7 CFR-15, Subparts A and B), which provide that no person in the United States shall on the grounds of race, color, national origin, age, sex, religion, marital status, or handicap be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving federal financial assistance from the Department of Agriculture or any agency thereof.

IN WITNESS WHEREOF, the parties hereto have caused this agreement to be executed:

For:

Agriculture and Home Economics Experiment Station, Iowa State University of Science and Technology (ISU)

E. Charles Brummer, Principal Investigator

19 Nov 97

Date

Ronald Cantrell, Department Executive Officer

12-11-97

Date

Colin Scanes, Associate Director

12/12/97

Date

Richard Hasbrook, Contracts & Grants Officer

12-12-97

Date

For:

Chariton Valley Resource Conservation and Development, Inc. (RC&D)

Leon Kauzlarich, Treasurer

12/18/97

Date

ATTACHMENT 5

Cooperative Agreement With ISU

COOPERATIVE AGREEMENT
Between
CHARITON VALLEY RESOURCE
CONSERVATION AND DEVELOPMENT, INC.
And
IOWA STATE UNIVERSITY DEPARTMENT OF ECONOMICS

I. **This Agreement** by and between Chariton Valley Resource Conservation and Development, Inc. (hereinafter referred to as RC&D) and Iowa State University Department of Economics (hereinafter referred to as ISU) shall be in full force and effect on and after the date of its final execution. The RC&D is a non-profit corporation, governed by a board of directors appointed by local units of government, State of Iowa, as provided for in the Iowa Code Chapter 504A.

II. **Purpose:** The RC&D and ISU have a shared interest in developing the biomass industry in Iowa. To that end, this agreement defines the terms of cooperation between the RC&D and ISU to conduct research activities for the Biomass Power for Rural Development Project underway in southern Iowa.

III. **Therefore,** the RC&D and ISU deem it mutually advantageous to cooperate as follows:

A. The RC&D agrees to:

1. Reimburse ISU in an amount not to exceed $52,700 for expenses incurred in completing the activities and products described in Section III. B. Reimbursement shall consist of $27,500 for the period extending from the date of final execution of this agreement through September 30, 1998 and $25,200 for the period of October 1, 1998 through September 29, 1999. Reimbursement will be made in response to periodic billings submitted by ISU.

2. Participate in the planning and review of activities and products described in Section III. B. and to help provide or arrange for assistance and support as needed and requested by ISU in fulfilling the terms of this agreement.

B. ISU agrees to complete the research tasks described in B.1. and B.2. below. Completion of the tasks and products described herein are not assignable without the prior written consent of the RC&D:

1. Determine the economic potential of switchgrass as an agronomic crop for bioenergy:

a. There is a need to document on-farm costs and resource commitments of producing switchgrass as a energy crop. A major goal of this task will be to understand the profitability of producing switchgrass for bioenergy relative to existing and alternative land uses. Production costs, technology development, acceptance by farmers, scale of production, and existence or development of a market all relate to profitability. Whole-farm budgets will be developed from as many as 6 case study farms in the Chariton Valley area. The results of this task will be used to prepare a draft agricultural extension bulletin detailing switchgrass production budgets, machinery complements, and labor and time costs.

b. There will be significant regional economic impacts as a result of planting 4,000 or more acres of switchgrass as a bioenergy crop in southern Iowa. Land currently in CRP is likely to be converted to switchgrass production first, followed by marginal cropland and pasture. The Iowa Economic/Fiscal Impact modeling System (IE/FIMS) will be used to identify and quantify city and county economic, employment, labor force, population, and fiscal impacts in response to changes in local or regional economies that result from large scale conversion of land to switchgrass production for bioenergy. The result of this task will be an agricultural extension publication describing the model assumptions, parameterization, and sensitivity of the impact estimates to changes in the assumptions.

c. On-farm energy consumption for machinery operation and inputs to produce switchgrass as a bioenergy crop have not been quantified. These energy expenditures will be compared to those associated with alternative land uses. Energy in terms of output will be evaluated in other parts of the Chariton Valley project. A major literature review will provide the basis for any background information that exists. The results of this task will either be incorporated into the previously mentioned extension bulletins or be used to prepare a draft agricultural extension bulletin itemizing energy budgets for switchgrass production as a bioenergy crop for electric power.

2. Prepare and submit monthly reports to the RC&D by the 15th of each month following the report month, an annual report on or about September 30, 1998, and a final report prior to September 29, 1999 that describe activities and findings related to completing the research tasks identified in III. B. Reports will include an accounting of any ISU in-kind contributions.

C. It is mutually agreed:

1. Completion Date: This agreement will remain in full force and effect from the date of its final execution through September 29, 1999. This agreement may be affirmatively renewed with the written consent of both the RC&D and ISU.

2. Intent to Cooperate: It is the intent of the RC&D and ISU to fulfill their obligations under this agreement. However, neither the RC&D or ISU shall be obligated beyond funds available.

3. Modification: This agreement may be modified by an amendment duly executed by authorized officials of both the RC&D and ISU.

4. Indirect Costs: No indirect costs are allowable under this agreement.

5. Termination: In the event that circumstances prohibit ISU or the RC&D from fulfilling the terms and conditions of this agreement, ~~the RC&D~~ either party may, at its discretion, declare this agreement null and void by providing ~~ISU~~ other party with 15 days advance notice in writing of such a decision. Upon giving of such notice, this agreement shall be rendered null and void and of no further force and effect.

LK REH/VVK

LK REH/VVK

6. Records of Data and Activities: Notebooks, records, and raw data related to the research shall be maintained in a retrievable form for a minimum of five years and will be made available upon request.

7. Quality Assurance and Environmental Protection: All instruments used in this research project will receive manufacturers' recommended maintenance and periodic calibration checks according to referenceable techniques and methods. Consideration will be given to the possible impacts of field trials on environmental quality and steps will be taken to avoid or minimize any adverse impacts.

8. Civil Rights Act: The activities conducted under this agreement shall be in compliance with the nondiscrimination provisions contained in the Titles VI and VII of the Civil Rights Act of 1964, as amended; the Civil Rights Restoration Act of 1987 (Public Law 100-259); and other nondiscrimination statutes: namely, Section 504 of the Rehabilitation Act of 1973, Title IX of the Education Amendments of 1972, and the Age Discrimination Act of 1975. They will also be in accordance with regulations of the Secretary of Agriculture (7 CFR-15, Subparts A and B), which provide that no person in the United States shall on the grounds of race, color, national origin, age, sex, religion, marital status, or handicap be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving federal financial assistance from the Department of Agriculture or any agency thereof.

IN WITNESS WHEREOF, the parties hereto have caused this agreement to be executed:

For:

Iowa State University
Department of Economics (ISU)

John A. Miranowski, Chair

12/1/97

Date

For:

Chariton Valley Resource Conservation
and Development, Inc. (RC&D)

Leon Kauzlarich, Treasurer

12/18/97

Date

Stanley R. Johnson
Vice Provost for Extension

12/1/97

Date

Richard E. Hasbrook
Contracts and Grants Officer

12/2/97

Date

ATTACHMENT 6

Rathbun Lake Watershed Project

RATHBUN LAKE
WATERSHED PROJECT

A Cooperative Approach to Protecting and Enhancing Land and Water Resources in South Central Iowa

RATHBUN LAKE WATERSHED PROJECT

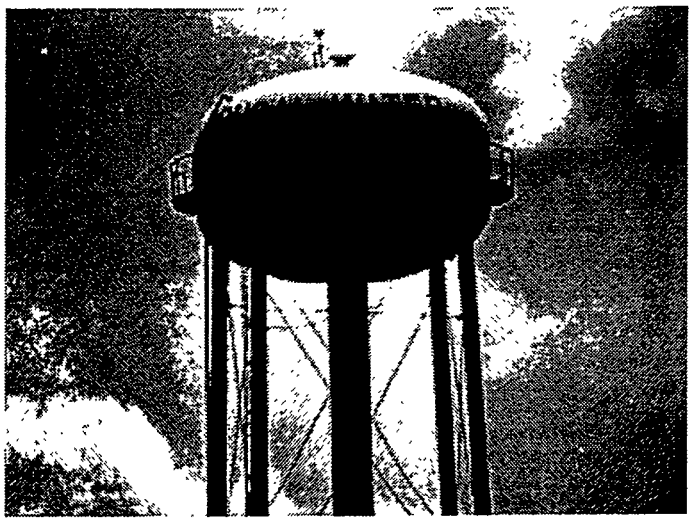
A Cooperative Approach to Protecting and Enhancing Land and Water Resources in South Central Iowa

INTRODUCTION

Rathbun Lake is one of the most important water resources in Iowa. The lake supplies water to Rathbun Regional Water Association (RRWA), one of the largest rural water systems in the nation. In addition, Rathbun Lake provides flood protection, fish and wildlife habitat, and recreational opportunities for one million visitors annually. Rathbun Lake is vulnerable to the impacts of agricultural nonpoint source pollution. Soil loss from highly erodible land in the watershed used for agricultural production is the primary cause of water quality impairment in the lake. Sediment transports farm chemicals into the lake, increases water treatment costs, limits recreational and wildlife values, and reduces water storage capacity. The most effective means of protecting water quality in Rathbun Lake is the proper use and management of land and water resources in the lake's watershed. The Rathbun Land & Water Alliance (RLWA), a cooperative effort between the six soil and water conservation districts (SWCD) in the watershed, provides the necessary framework for land owners, public agencies, and private organizations to effectively plan and implement measures to protect water quality in the lake.

RATHBUN LAKE AND WATERSHED

Rathbun Lake and its watershed are located in Iowa's 1997 Environmental Quality Incentives Program (EQIP) priority area number one. Rathbun Lake is located on the Chariton River in south central Iowa. The 11,000 acre lake was developed by the US Army Corps of Engineers (ACOE) in the 1960's as a multi-purpose facility. Rathbun Lake provides flood protection for 150,000 acres of land, fish and wildlife habitat in the lake itself and on 21,000 acres of adjacent public land, and recreational opportunities for one million visitors annually. Rathbun Lake is a critically important water supply for southern Iowa and northern Missouri. RRWA, one of the largest rural water systems in the country, provides potable water from the lake to more than 50,000 residents in 14 counties and 21 communities. RRWA officials expect increased demand for water over the next five years. As such, RRWA has taken steps to double its capacity in order to satisfy the future water needs of the region.



One of Rathbun Regional Water Association's 27 elevated storage tanks.

The watershed of Rathbun Lake includes over 570 square miles or about 365,000 acres. Row crop production is the principal land use with corn and soybeans being the most commonly grown crops. Pasture and hayland comprise about one quarter of the land use in the watershed. Soils developed primarily from weathered glacial till and loess deposits. Many of the soils are highly erodible and poorly suited for intensive row crop production. More than one third of the watershed, close to 133,000 acres, consists of highly erodible cropland. Over 56,000 acres of this highly erodible cropland are currently enrolled in the Conservation Reserve Program (CRP). Soils adjacent to many of the larger streams and tributaries are subject to frequent flooding. An estimated 400 cow/calf operations and 300 livestock open feedlots and confinement operations are located throughout the watershed.

Table 1. Land Use in the Rathbun Lake Watershed

	Cropland	Pasture & Hayland	Woodland	Other (Urban Water Road, Etc.)
Percent of Watershed	60	24	7	9
Acres	219,146	87,659	25,567	32,872

Counties in the Rathbun Lake watershed include Appanoose, Clarke, Decatur, Lucas, Monroe, and Wayne. According to Iowa State University (ISU), the six counties in the watershed are among the least prosperous in Iowa. These counties suffer some of the highest poverty and unemployment rates and lowest levels of income and farm sales in the state. Approximately 15,000 people live in the Rathbun Lake watershed. Most of the residents live in rural areas. The majority of these residents own and farm land in the watershed. There are 800 farms and nine communities in the watershed. At least 15% of the farms in the watershed are owned and operated by woman (10%) and minority (5%) producers. Special mention should be made of the fact that the majority of farms are family operations in which both male and female producers actively participate. Given the overall relatively poor economic conditions of counties in south central Iowa, it is no surprise that close to 60% of the producers in the watershed are considered small scale/limited resource (socially disadvantaged) farmers.

Table 2. Counties in the Watershed

Counties	Acres and Percentage of Land in Watershed
Appanoose	55,311 (15%)
Clarke	16,239 (4%)
Decatur	6,178 (2%)
Lucas	94,857 (26%)
Monroe	7,054 (2%)
Wayne	185,605 (51%)
Total	365,244

WATER QUALITY AND RELATED CONCERNS

Protection and improvement of the quality of water in Rathbun Lake is the primary natural resource issue that will be addressed by this project. Of particular concern is Rathbun Lake's importance as a water supply for residents, farms, businesses, and industries in southern Iowa and northern Missouri. Water quality in Rathbun Lake is directly related to other issues of concern in the region. Sediment that impairs water quality in the lake is the result of excessive soil loss from land in the watershed. Soil loss at such high rates is a significant threat to this land's long term agricultural productivity and the farm-dependent economies of the region. In addition, outdoor recreation and tourism that center around Rathbun Lake and associated resources have become increasingly important economic activities for communities and rural areas in south central Iowa. Deterioration of water quality in the lake and its impact on fish, wildlife, and outdoor activities will have an enormously detrimental effect on this growing segment of the region's economy.

According to the Iowa Department of Natural Resources (DNR), agricultural nonpoint source pollution is the leading cause of water quality impairment in the state and is responsible for the fact that all of Iowa's streams and rivers are considered to be threatened by pollution. Recent studies have found detectable levels of pesticides in all of the surface waters sampled during the growing season in Iowa. A number of public drinking water sources have had year-round levels of pesticides above the maximum contaminant levels set by the US Environmental Protection Agency (EPA). In 1986, the State of Iowa sampled 33 reservoirs and rivers used for drinking water. The results indicated that 21 of those public water sources had at least one pesticide at concentrations above the lifetime health advisories issued by the EPA. Soil loss from land used for agricultural production is a major threat to surface water resources in Iowa. Sediment, as well as being a vehicle for transporting agricultural chemicals into surface water, increases water treatment costs, reduces recreational and wildlife values, and can significantly shorten the useful life of reservoirs. A recent survey conducted by ISU found that 84% of the residents in Iowa consider water pollution to be a serious problem in the state. Agricultural activities including pesticide and fertilizer use were identified by survey respondents as primary sources of water quality impairment.

Rathbun Lake is vulnerable to the impacts of agricultural nonpoint source pollution. According to the ACOE, Rathbun Lake is filling with sediment at a rate which is more than 30% faster than originally anticipated. Continued sedimentation at current rates will greatly reduce the lake's long term usefulness as a drinking water source, recreational attraction, and habitat for fish and wildlife. In addition to the loss of water storage capacity, sediment causes severe turbidity problems in the lake. High turbidity levels increase the difficulty and cost of water treatment and limit wildlife habitat and recreational values. Studies of contaminant levels in drinking water sources in Iowa found that Rathbun Lake was one of 13 public water supplies with average summer atrazine and/or cyanazine concentrations above the US EPA lifetime health advisory. The presence of agricultural chemicals in drinking water supplies can greatly increase treatment costs and have serious long term consequences for the health of water users. Increased awareness and knowledge of threats to water quality in Rathbun Lake have caused a heightened level of concern among residents, public officials, and resource professionals in south central Iowa. Given the importance of Rathbun Lake as a public water supply, major recreational attraction and wildlife resource, the potential impact of impaired water quality in the lake is enormous.

SOURCES OF WATER QUALITY IMPAIRMENT

Six sources of water quality impairment that threaten Rathbun Lake have been identified. These sources are briefly described below:

1. Sediment And Chemicals From Cropland

Approximately 60% of the land use in the watershed is cropland. Well over one half of this cropland, close to 133,000 acres, is highly erodible. Sheet and rill erosion on highly erodible cropland in the watershed can exceed 30 tons per acre per year. Runoff from cropland areas, particularly highly erodible land, that carries sediment and agricultural chemicals is the major source of water quality impairment in Rathbun Lake. Over three-quarters of the land in the watershed that is currently enrolled in CRP, more than 44,000 acres, will be released from the program in the next two to three years. It is expected that as many as 10,000 acres of this highly erodible land will not be re-enrolled in the program. Land owners have indicated that, under current conditions, as much as 80% of land released from CRP in the watershed will be converted to row crop production. The use of this and other highly erodible land in the watershed to produce row crops, without needed conservation measures, will increase the amounts of sediment and farm chemicals that enter the lake.

Soil loss from cropland is a primary source of water quality impairment in Rathbun Lake.

2. Gully Erosion

Severe gully erosion occurs on land throughout the watershed. While most frequently a problem on highly erodible and sloping non-highly erodible cropland, significant gully erosion also occurs on poorly managed pasture and hayland. It is estimated that gully erosion is a source of soil loss on at least 21,000 acres of land in the watershed. Sediment delivery from gully erosion is a particular threat to Rathbun Lake due to the fact that as much as 90% of the eroded materials reach the Lake.

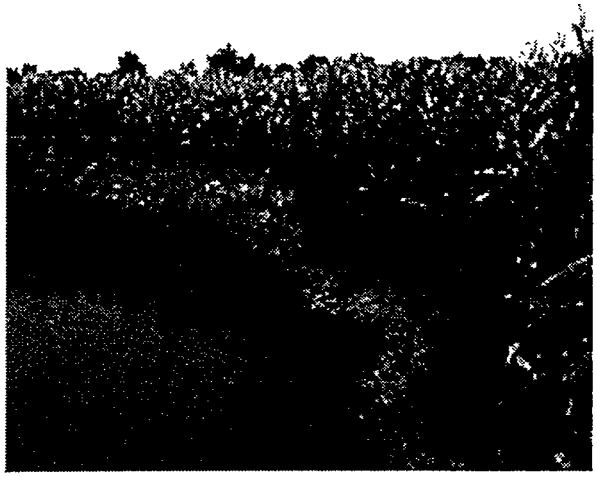
Gully erosion in the watershed contributes large amounts of sediment to Rathbun Lake.

3. Soil Loss From Pasture And Hayland

Pasture and hayland in the watershed consists primarily of introduced cool season grasses. More than 63,000 acres, 70% of the pasture and hayland in the watershed, are in a degraded condition due to low levels of management. Recent inventories have found that ground cover on these poorly managed pasture and hayland acres can be as low as 50% with up to half of the vegetation present being weeds. Pasture and hayland in this condition suffer excessive soil loss with rates as high as 15 tons per acre per year. In addition, overgrazing of pasture has severely degraded riparian areas in the watershed. Stream bank erosion caused by uncontrolled livestock access to these areas is another significant source of sediment that impairs water quality in Rathbun Lake.

4. Shoreline And Stream Bank Erosion

Significant water level fluctuations in the flood control storage area of Rathbun Lake are common throughout the year. These fluctuations in lake level occur as a result of storm events in the watershed and water release guidelines designed to protect downstream land and infrastructure from flooding. Inundation of the control area of the lake for extended periods destroys existing vegetation, making the shoreline and affected stream banks very susceptible to erosion. A large percentage of the 180 miles of shoreline at Rathbun Lake is impacted by the resulting wave erosion. A significant portion of the sediment that affects Rathbun Lake is contributed by this shoreline and stream bank erosion.



Stream bank erosion is another source of sediment that affects Rathbun Lake.

5. Waste From Livestock Operations

Many of the 300 livestock open feedlot and confinement facilities located in the watershed are considered potential sources of contaminants that contribute to water quality impairment in Rathbun Lake. Animal waste from these livestock operations are suspected of causing excessive growth of algae and increased levels of bacteria in the Lake and streams in the watershed. DNR regulations require open feedlot and confinement operations to meet certain animal waste control standards. Currently, few of these facilities in the watershed have an animal waste management system or utilization plan which completely satisfies the DNR minimum waste control requirements.

6. Waste Water And Sediment From Residential Areas

Many of the residential and business septic systems in the watershed do not function properly. The primary reason for this is that the design, installation, and management of these systems do not adequately take into consideration the physical limitations of soils in the area for waste water disposal. In addition, four of the nine communities in the watershed do not have central sanitary sewer systems for their residents. The attractiveness of Rathbun Lake and the surrounding region has led to an increase in the construction of houses in rural areas of the watershed. Rarely do these construction projects take measures to reduce soil loss and minimize impacts to water quality in the lake. Waste water and sediment from residential areas, while not primary sources of water quality impairment, are issues that require special attention and approaches to water quality protection.

RATHBUN LAKE WATERSHED PROJECT

Water Quality Protection Efforts Underway

The relationship between Rathbun Lake and the people who depend on this resource for drinking water, recreation, and community and economic development is unique. In many instances, the people who rely on a water resource such as Rathbun Lake have very little control over activities that may affect the resource. This is not the case with Rathbun Lake. Residents in the watershed are not only those individuals who benefit most from the Rathbun Lake, e.g., the majority receive their water from RRWA, but are also the people whose actions most directly impact the lake. Given the importance of this unique relationship, success in protecting water quality in Rathbun Lake will depend on a locally planned and implemented program of education, technical support, cost share assistance. Recognizing this, water quality protection efforts currently underway include:

Members of the Rathbun Land & Water Alliance discuss efforts to protect water quality in Rathbun Lake.

Creation of the Rathbun Land & Water Alliance (RLWA). The six SWCDs in the Rathbun Lake watershed have worked together to facilitate the local planning activities that led to development of this EQIP priority area proposal. The Rathbun Lake Watershed Project has been designated as the number one priority by the four SWCDs that encompass the majority of the watershed, Appanoose, Lucas, Monroe, and Wayne. The project is the number two priority for the SWCDs in Clarke and Decatur Counties where significantly less area of the watershed is located. The RLWA is a result of the coordinated efforts of these Districts to address water quality issues that affect Rathbun Lake. The RLWA is comprised of local land owners, elected officials, and representatives from public agencies and private organizations. The purpose of the RLWA is to provide local direction to, and promote cooperation in, efforts to protect and enhance land and water resources in Rathbun Lake and its watershed. RLWA is organized as a nonprofit corporation under provisions of the Iowa Code Chapter 504A.

Survey of Land Owners and Water Users. The RLWA and ISU are conducting a survey of land owners and water users in the watershed of Rathbun Lake. The survey will provide local input on water quality issues and water quality protection efforts related to Rathbun Lake and its watershed. Survey results will be used to help members of the RLWA better address issues of importance to residents and improve the planning and implementation of efforts to protect water quality in Rathbun Lake.

Water Quality Monitoring Program. The RLWA, US Geological Survey (USGS), DNR, and US ACOE have initiated a cooperative water quality monitoring program for Rathbun Lake. The monitoring program will gather and analyze data on nutrients, chemicals, and sediment that enter the lake from specific areas of the watershed and the amounts of these pollutants in the Lake itself. Results of the monitoring program will guide water quality protection efforts toward those areas of, and activities in, the watershed that have the greatest impact on Rathbun Lake.

Development of a Geographic Information System (GIS). The RLWA, in cooperation with Chariton Valley Resource Conservation and Development (RC&D) and the SWCDs, are in the process of creating a GIS for the Chariton River valley, including Rathbun Lake and its watershed. GIS data layers developed include soils, land use, land cover, infrastructure, public land, and others needed to improve the planning, implementation, and tracking of water quality protection efforts.

Employ an Environmental Specialist. The Iowa Department of Agriculture and Land Stewardship's Division of Soil Conservation (IDALS DSC) has agreed to provide the funding needed for an Environmental Specialist position. The Environmental Specialist will assist the RLWA to complete a comprehensive water quality assessment of the watershed, prioritize areas of the watershed for the application of water quality protection measures, work with land owners to help them avoid negative impacts to water quality from their farming operations, and develop a water quality education program for the public.

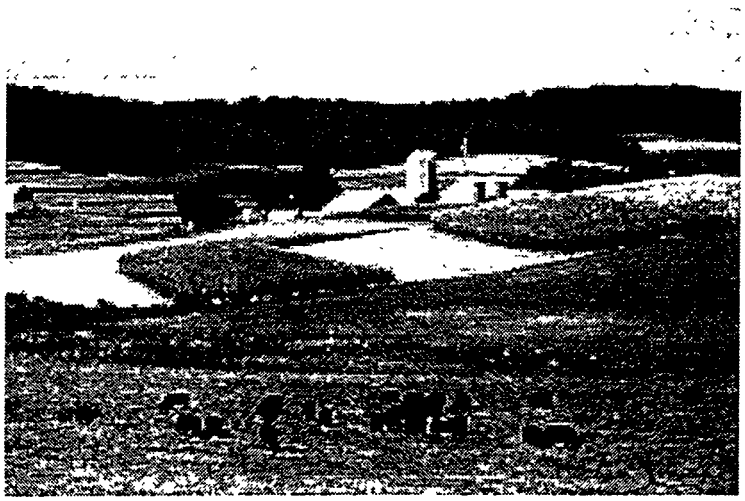
Prepare Water Quality Protection Project Proposals. SWCDs and Chariton Valley RC&D are assisting the RLWA with the preparation of proposals to help fund water quality protection activities in the Rathbun Lake watershed. These proposals have been, or will be, presented to the EPA, DNR, and Natural Resources Conservation Service (NRCS). Funds requested in these proposals will support land owner education and training and provide cost share assistance to accelerate the application of water quality protection measures. Local sponsors for these water quality protection projects include the SWCDs, RRWA, county and city governments, Farm Bureau, and Chariton Valley RC&D.

Chariton River Corridor Development. More than 8,000 acres along the Chariton River, above and below Rathbun Lake, have been converted from row crop production to wildlife habitat, woodland, and recreational use. Much of this land has been, and continues to be, restored to wetland and riparian habitat. The conversion of cropland in the corridor to these more appropriate uses will reduce the damage and cost of future floods, improve water quality in the Chariton River and Rathbun Lake, provide opportunities for recreation and tourism-based economic development, and increase habitat for important game and non-game wildlife species. The ACOE, NRCS, US Fish and Wildlife Service, DNR, county governments, and private organizations including the Iowa Natural Heritage Foundation, National Fish and Wildlife Foundation, and Chariton Valley RC&D have contributed technical and financial assistance to habitat restoration efforts in the Chariton River corridor.

Wetland restoration on the Chariton River upstream from Rathbun Lake.

PROJECT GOALS

The most effective means of protecting water quality in Rathbun Lake is the proper use and management of resources in the lake's watershed. In order to accomplish this, land owners in the watershed, in partnership with public and private organizations, must take an active role in identifying and addressing concerns and activities that have an impact on water quality in the lake. The RLWA provides the organizational framework for this cooperative approach to protecting land and water resources in south central Iowa in general and Rathbun Lake in particular. Specifically, goals for the Rathbun Lake Watershed Project include:



Proper land use is the key to protecting water quality in Rathbun Lake.

- Complete an assessment of sources of water quality impairment that threaten Rathbun Lake in order to better target areas of the watershed for water quality protection measures.

- Continue development of a geographic information system to assist with planning, tracking, and evaluating the application and effectiveness of water quality protection measures.

- Accelerate the application of water quality protection measures by securing and directing local, state, and federal technical and financial assistance to targeted areas of the watershed.

- Complete the survey of residents and land owners in the Rathbun Lake watershed to obtain local input on water quality and water quality protection.

- Continue the water quality monitoring program for Rathbun Lake to evaluate the effectiveness of soil and water conservation practices applied in the watershed.

- Conduct educational activities that will encourage and enable producers to implement measures to protect the water quality in Rathbun Lake.

- Support efforts in the Chariton River corridor to restore wetland and riparian habitat and promote associated wildlife and recreational benefits on land best suited for those purposes.

- Identify and pursue rural economic development opportunities that rely on the sound use of land and water resources in south central Iowa.

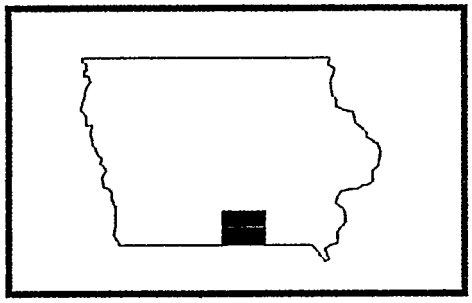
Swtichgrass in the watershed being harvested for use as biofuel.

CHARITON VALLEY BIOMASS PROJECT

"Switchgrass to Energy"

The Iowa Project in the U.S. Department of Energy Initiative
Biomass Power for Rural Development

BIOMASS POWER PROGRAM



The Chariton Valley RC&D Area is composed of Appanoose, Monroe, Lucas and Wayne Counties in south central Iowa. RC&D facilitates rural and economic development through coordination, planning, creative financing and demonstration. Much of the industrial and community development in the area has benefited from RC&D assistance.

Concerns over intensive use of natural resources, a declining rural population, and changing environmental policies have caused the RC&D to delve into research and development directed toward alternative agriculture and markets for the sustainable use of local resources.

PROJECT PARTNERS

Chariton Valley RC&D would like to recognize a growing list of participants and sponsors for their valuable assistance and contributions to the project. These partners are providing financial and technical assistance for this project.

Private Sector Partners

IES Utilities
Located in Cedar Rapids, Iowa, IES is a major energy producer in the state and has agreed to co-fire switchgrass contingent upon a successful feasibility study.

R. W. Beck
International engineering firm with project assistance coming from the Madison Wisconsin office. Providing design services and general project assistance and coordination. Responsible for engineering and feasibility determination of the IES co-firing project.

Energy Research Corporation
Private firm with expertise in gasification and fuel cells working with ISU to evaluate the application of this technology to the use of switchgrass for energy generation.

Iowa Farm Bureau Federation
Major farm sector advocacy organization, active in farm policy issues and in providing individual services to local farms. Providing assistance with public information and serving as primary liaison with producers.

John Deere Works
The worldwide forage research unit for John Deere, Inc., located in Ottumwa, Iowa, is providing major support in the area of harvest and handling technology research and development.

Prairie Lands Bio-Products
A switchgrass producers organization that works with other partners to conduct project research, develop management and harvest techniques, and ensure a supply of switchgrass for energy generation.

Public Sector Partners

US Department of Energy

Iowa State University

Iowa Energy Center

Iowa Department of Natural Resources

USDA Natural Resources Conservation Service

USDA Rural Development

USDA Farm Service Agency

Iowa Division of Soil Conservation

Leopold Center For Sustainable Agriculture

Oakridge National Laboratory

National Renewable Energy Laboratory

Soil and Water Conservation Districts of Lucas, Wayne, Monroe, and Appanoose Counties

Chariton Valley RC&D, RR 3, Box 116A, Centerville, IA 52544
Ph: 515/437-4376 Fax: 515/437-4638 E-mail: cvrcd@se-iowa.net
12/97;jb

BIOMASS POWER PROGRAM

Rural Development Impacts

Producing switchgrass as a renewable energy crop on land in southern Iowa will:

- Create new markets for a native forage
- Provide a profitable alternative for marginal lands
- Increase income and create job opportunities in rural areas
- Reduce Iowa's energy dependency

Environmental Benefits

Switchgrass production as an energy crop can provide a number of environmental benefits including:

- Protection of water quality
- Erosion control and improved soil quality
- Carbon sequestration and avoidance
- Reduced coal plant emissions

Loading switchgrass bales for use as fuel.

Current Project Highlights

- IES Utilities and R.W. Beck are designing modifications to the IES Ottumwa Generating Station that will allow the co-firing of switchgrass with coal at that 726 MW facility. Tentative plans call for these modifications to be made in early 1999 with a co-fire test to be held later that year.

- Chariton Valley RC&D, ISU, John Deere, and Prairie Lands Bio-Products are conducting field level research to improve switchgrass yields, management practices, and fuel characteristics. The results of this research will increase the competitiveness of Iowa switchgrass as a source of renewable energy.

- USDA agencies, Iowa DNR, and Chariton Valley RC&D are cooperating in the development of a Geographic Information System (GIS) for the project area. The GIS will be used to coordinate the supply of switchgrass and to evaluate the environmental benefits of producing switchgrass as an energy crop.

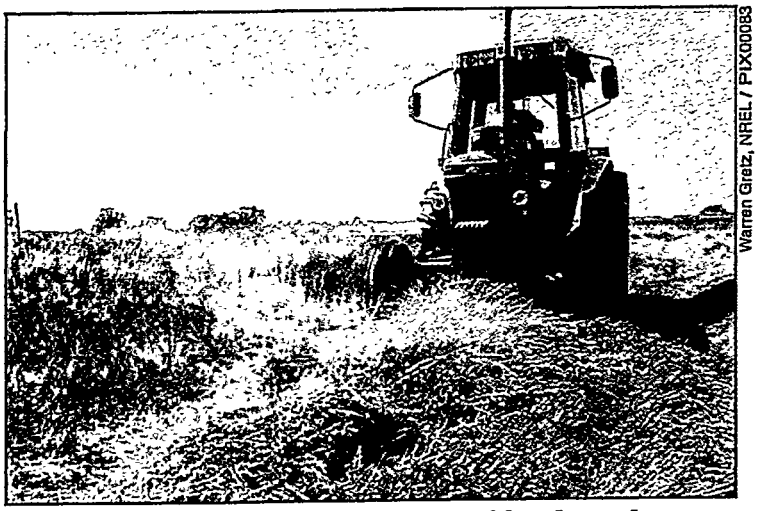
- Prairie Lands Bio-Products, Iowa Farm Bureau, and the RC&D are developing a number of near-term products and markets that will help increase the supply of switchgrass. These include the manufacture of fuel pellets and logs, fiberboard, paper, and its use as animal bedding and mulch.

- Project partners including the Iowa Division of Soil Conservation, Iowa DNR, and ISU are evaluating the environmental benefits of producing switchgrass as an energy crop. These benefits include soil conservation, water quality protection, improved wildlife habitat, and a reduction in atmospheric carbon.

Field demonstrations inform the public and promote project objectives.

Chariton Valley RC&D, RR 3, Box 116A, Centerville, IA 52544
Ph: 515/437-4376 Fax: 515/437-4638 E-mail: cvrcd@se-iowa.net

02/98;jb



Switchgrass can be grown on marginal lands, and provides benefits such as a habitat for wildlife and erosion control.

Iowa Switchgrass

Iowa's Chariton Valley RC&D, Inc., will grow switchgrass on 40,000 acres of underutilized, marginal cropland as energy crops for 35 MW of co-fired power.

Project Overview

The prime objective of the cooperative agreement with Chariton Valley Resource Conservation and Development, Inc. (RC&D), is the development of markets for energy crops in southern Iowa. Chariton Valley RC&D will transform switchgrass now used for erosion control into a cash energy crop that will generate up to $200 per acre. The main highlights of the project are:

- Development of 35 MW of co-fired capacity using switchgrass in an existing coal power plant.
- Investigation of up to 6 MW of capacity from switchgrass gasification.
- 30,000–40,000 acres of switchgrass grown on Conservation Reserve Program (CRP) lands will control erosion and minimize fertilizer and pesticide applications in the targeted watershed, which supplies water to 13 counties and 21 cities.

Long-Term Goals and Objectives

Chariton Valley RC&D, representing a diverse consortium of public and private partners, proposes to pursue relocation of a 6-MW gasifier to be fueled by switchgrass grown on 4000 acres of CRP land authorized by the U.S. Department of Agriculture. Also, 36,000 additional acres of switchgrass will be dedicated for co-firing with coal for the production of 35 MW of biomass-based generation capacity by the year 2000. Up to 500 local farmers will have the opportunity to sell the new cash crop to power companies. Growers will be paired with project team members offering expertise from a number of public- and private-sector organizations.

Recent Accomplishments

- Of the 4,000 acres of CRP land needed for this cooperative development program, 3,000 acres have been signed up.
- The Iowa Farm Bureau is currently working to establish a grower's cooperative to facilitate the development of energy and coproducts from switchgrass.

Near-Term Plans

- Establish a switchgrass grower's cooperative by the end of 1997.
- Continue development of methods to maximize establishment, yield, and handling of switchgrass on 330 acres of land with the additional conversion of 4000 acres of CRP land.
- Complete, detailed design and site plans for the boiler modifications and handling facilities of the IES Ottumwa Generating Station in 1997; ABB Combustion Engineering is to perform switchgrass test firings to optimize design parameters for IES.
- Iowa State University will develop switchgrass gasification processes.
- Energy Research Corporation will investigate utilization of switchgrass product gas in fuel cells.

Chariton Valley RC&D's Phase II application is due in July 1998. DOE plans to invest nearly $6 million in Phases I and II, which have an estimated total project cost of nearly $13 million.

Project Partners

- Chariton Valley RC&D
- IES Utilities, Inc.
- Iowa State University
- ABB Combustion Engineering
- Energy Research Corporation
- Iowa Division of Natural Resources
- John Deere Company
- R.W. Beck
- Iowa Farm Bureau Federation
- Many local farmers/producers

This document was produced for the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory, a DOE national laboratory.

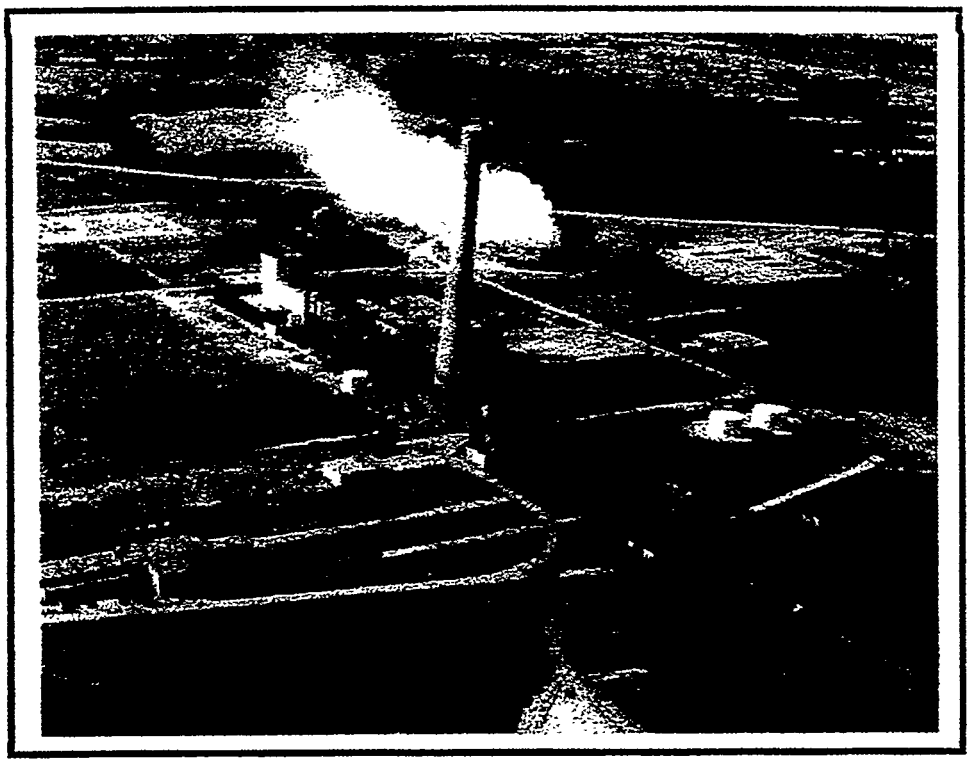
DOE/GO-10097-414
August 1997

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste

BIOMASS POWER PROGRAM

Ottumwa Generating Station
Ottumwa, Iowa

Type: Steam Turbine
Total Generating Capacity: 387.1 MW (IES share)
Fuel: Coal
Owned by: IES Utilities (48%) and MidAmerican Energy (52%)
Operated by: IES Utilities
Began commercial operation in 1981
Listed as a "Top 20" performer for 1995 in the November 1996 issue of *Power Engineering* magazine (ranking based on production costs and operating performance).



Chariton Valley RC&D, RR3, Box 116A, Centerville, IA 52544
Ph: 515/437-4376 Fax: 515/437-4638 E-mail: cvrcd@se-iowa.net

Complete the form on the back side of this brochure, detach, and mail $20 membership fee to:

Prairie Lands Bio-Products, Inc.
RR 3 Box 116 A
Centerville, IA 52544

Phone: 515-437-4376
Fax: 515-437-4638

Prairie Lands Board of Directors

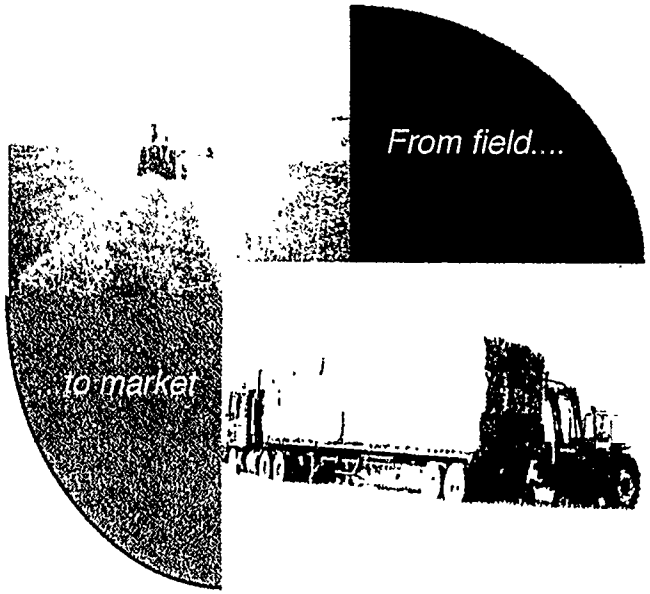
President	Ed Robinson	515-724-3530
1st Vice-president	John Sellers	515-872-2657
2nd Vice-president	Don Clark	515-437-4740
Secretary	Jim Schweizer	515-437-4271
Treasurer	Loren Eddy	515-856-2223

The board meets monthly. Contact a member for meeting date.

Photo of board of directors

The Chariton Valley Biomass Project is funded in part by: The Leopold Center for Sustainable Agriculture, United States Department of Energy, and United States Department of Agriculture.

Prairie Lands Bio-Products, Inc.



March, 1998

What is Prairie Lands?

Prairie Lands Bio-Products, Inc. is a not-for-profit organization with a current membership of close to 30 switchgrass growers. Prairie Lands membership has elected a board of directors (listed on back) to oversee the activities of the organization. Prairie Lands members are working to accomplish the following:

- *Identify and develop switchgrass products and markets for those products;*
- *Produce switchgrass to satisfy demand for products;*
- *Evaluate environmental benefits of producing and using switchgrass; and*
- *Inform and educate the public about the potential of switchgrass.*

In addition, Prairie Lands is one of many private and public partners cooperating with the Chariton Valley RC&D on the Chariton Valley Biomass Project.

Why switchgrass?

Switchgrass, a warm season grass native to Iowa, grows well in a wide range of soil and weather conditions. The versatility of switchgrass makes it useful for grazing, mulch, animal bedding, as well as an energy fuel.

For more information about Prairie Lands and switchgrass, contact a member of the board of directors.

Benefits

Switchgrass production and use, particularly on marginal land, can improve soil quality, reduce erosion, protect water quality, aid in carbon sequestration, and enhance wildlife habitat.

Potential markets

Currently, Prairie Lands is evaluating the feasibility of producing and marketing switchgrass for potential markets. Those markets include:

- *Pellets and logs for use in stoves and furnaces;*
- *Mulch for landscaping;*
- *Fiberboard and paper;*
- *Animal bedding; and for*
- *Use as feed stock for co-fire at IES Utilities Ottumwa Generating Station.*

Benefits of membership

Membership offers the following benefits:

- *Technical assistance with the establishment and management of switchgrass;*
- *Current information on product developments;*
- *Opportunities to participate in new markets;*
- *Regular updates about the Chariton Valley Biomass project; and*
- *Opportunities to participate in demonstrations and research activities.*

Membership fee of $20 includes quarterly updates.

Name_____

Address_____

Phone ( )_____

Fax ( )_____

Do you grow switchgrass? ___Yes ___No

If yes, how many acres?_____acres

Are you interested in planting switchgrass? ___Yes ___No

If yes, how many acres?_____acres

Attachment A

Biomass Project Information and Education Activities and Products:

Project Update: Computer file (Mac format) and hard copy versions delivered for reproduction and distribution. Project Update will be revised as requested but no less often than every 3 months.

Project Press Releases: Computer file (Mac format) and hard copy versions delivered to for reproduction and distribution. Press releases will be developed as requested but no less often than monthly. A complete and updated database of media contacts and addresses will be provided with the press releases. Follow-up will be made with media contacts to encourage press coverage. Provide documentation of coverage.

Project News Stories: Computer file (Mac format) and hard copy versions delivered for reproduction and distribution. News stories will be developed as requested but no less often than monthly. A complete and updated database of media contacts and addresses will be provided with the news stories. Follow-up will be made with media contacts to encourage press coverage. Provide documentation of coverage.

Project Media Events: Plan, organize, and conduct project media events as requested but no less often than one event every 3 months. Provide documentation of coverage.

Project Displays: Develop and update materials for at least 2 project displays. Displays will be updated as requested but no less often than every 3 months. Shared responsibility with ISU Extension.

Project Slide Presentation: Develop and update one project slide presentation (with copy). The presentation will be updated as requested but no less often than every 3 months.

Project Field Days and Demonstrations: Develop and update materials including signs as needed for project field days and demonstrations. Shared responsibility with ISU Extension.

Project Web Site: Coordinate the continued supply of up-to-date information from project partners to ISU for use on the project web site.

Coordination: Coordinate activities and products with the project's information and education advisory committee. Communicate with project partners as needed but not less often than monthly regarding information and education activities and products including requests for contributions and to report on accomplishments.

Reports: Cooperate with the project's information and education advisory committee to prepare and submit annual and final reports and periodic billings to the Leopold Center for Sustainable Agriculture.

Education efforts

I would like to introduce myself with this issue of *Switchgrass to Biomass.*

I am Kathleen Chester and have been contracted to work on the information and education portion of the Chariton Valley Biomass Project.

One of those efforts includes continuing this newsletter, which will be published quarterly beginning with this issue.

Current information and education efforts are as follows:

- a brochure designed specifically for Prairie Lands;
- the development of a product display for use at school and civic presentations; and
- a news story defining the Prairie Lands organization.

I am available by phone every day except Friday at 515-774-5940 and by internet e-mail, *chester@ecity.net.*

I welcome your information ideas and look forward to meeting more project partners.

Switchgrass to Biomass

Vol. 2 Issue 1 *January, 1998*

Published for the Chariton Valley Biomass Project

Project nears goal

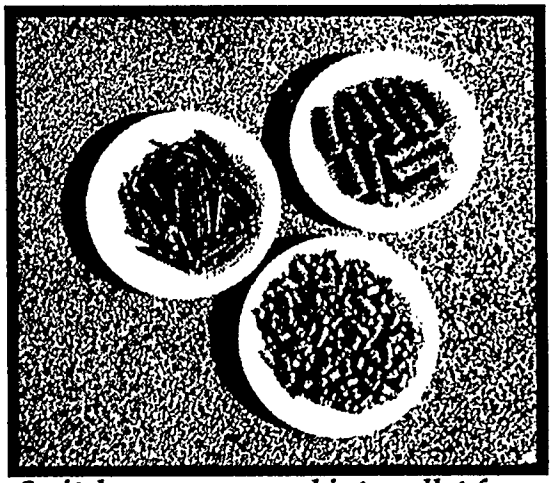
The goal of securing 4,000 CRP acres of switchgrass for project use is closer to reality. Switchgrass is either scheduled to be planted or is already established on most of the projected 4,000 acres needed for this phase of the project.

Kansas City pellet mill

Alan Teel, project field specialist, traveled to Kansas City, Missouri, along with Prairie Lands members, Jim Schweizer and Don Clark, with a load of switchgrass in the on-going effort to locate a manufacturer to convert switchgrass to pellet form.

Although it was determined the Kansas City mill would not be able to serve as the pellet manufacturer, they returned home with 1,500 pounds of pellets for use in the feasibility study. *(See article on page 2 of this newsletter.)*

In addition to the pellets, the two returned with valuable information in regard to meeting quality specifications for the home heating industry.



Switchgrass processed into pellet form.

Feasibility study

Funding has been awarded through a USDA grant to study the feasibility of producing and marketing switchgrass fuel products.

Ed Woolsey of E.L. Woolsey & Associates has been contracted as consultant to this study. In addition, Ed serves in the capacity of Chariton Valley Biomass Project Manager.

Ed's familiarity with the project, along with his expertise in renewable energy will be a valuable asset to the project.

Objectives of the study are to identify production costs as well as compare costs with competing fuels.

Another goal is to develop a market for switchgrass fuel products such as pellets and logs.

The Chariton Valley Biomass Project is funded in part by: The Leopold Center for Sustainable Agriculture, United States Department of Energy, United States Department of Agriculture, Farm Bureau, and Iowa Department of Natural Resources.

The RC&D program is a USDA rural development program administered by the USDA Natural Resources Conservation Service per Public Law 97-98.

About 1,500 pounds of pellets which were made at a Kansas City pellet mill will be distributed to consumers for evaluation in their pellet burning stoves.

One of the test stoves belongs to Prairie Lands member, Gary Bernell. Pellets will be burned at Southern Iowa Equipment in Moravia, as well.

A questionnaire will be given to those who burn the pellets and will be used as an evaluation tool to measure the pellets effectiveness as a heating source.

Plans are that up to five hundred tons of switchgrass will be processed and test marketed in its various forms.

As part of the study, Mike Wise, of Universal Milling Technology, will develop a equipment diagram for a proposed pellet mill.

The Furrow stirs interest

The recent article published in John Deere's, *The Furrow*, highlighting the Chariton Valley Biomass Project, has generated interest in the production and use of switchgrass throughout the United States and Canada.

Alan Teel, project field specialist, reports interest from a farmer in New York who wants more information about the use of switchgrass as a mulch and bedding.

A possible seed purchase inquiry came from Saskatchewan, Canada.

A Department of Energy research center in Pittsburgh, Pennsylvania, which works with coal and coal products, has requested two tons of switchgrass for a co-firing experiment in a laboratory setting.

Even a debate team out of Kansas requested information for use in a debate about renewable energy.

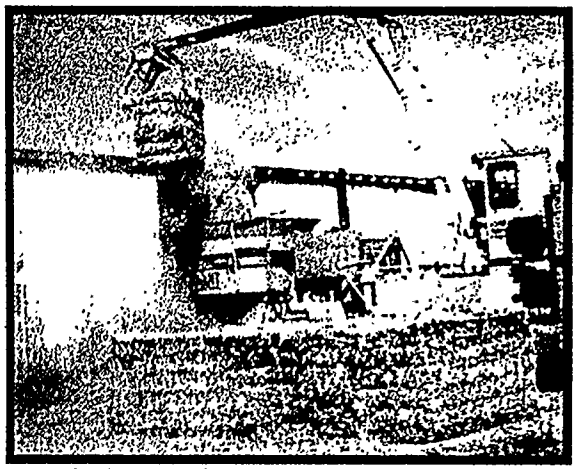
reprint removed

Demonstration held

A tub grinding demonstration was held near Millerton, Iowa in late November. The objective was to evaluate and demonstrate the use of a tub grinder to process switchgrass for co-firing at the Ottumwa Generating Station.

Comparisons were made in handling large square bales and large round bales.

Project partners present at the demonstration included: Chariton Valley RC&D; USDA; United States Department of Energy; National Renewable Energy Lab; R.W. Beck; ISU Extension; and Prairie Lands Bio-Products members.



Switchgrass is processed in tub grinder.

ATTACHMENT 7

Newspaper Articles and Information Publications

- Chariton Valley Biomass Project "Switchgrass to Energy"
- Prairie Lands Bio-Products, Inc. Publication - March 98
- Iowa Farmer Today - Feb 98 "Southern Iowa ready to flip switch on switchgrass test" reprint removed
- Switchgrass to Biomass Publication - January 98 reprint removed
- Biomass Project Info and Education Activities and Products
- The Furrow - 1998 Special Forage Issue "New life for a forgotten grass" reprint removed
- Successful Farming - December 97 "Sold on switchgrass" reprint removed
- Ad Express-Iowegian December 97 "Switchgrass project continues" Reprint Removed
- Albia Union-Republican - Dec 97 "Switchgrass demo has wide following" Reprint removed
- Chariton Leader - Dec 97 "Lucas county fields may go back to future" Reprint removed
- Wallaces Farmer - Nov 97 "Switchgrass - A renewable energy crop on land in southern Iowa" Reprint removed
- Ottumwa Courier - Nov 97 "Biomass project hopes to create new energy source" Reprint removed
- Des Moines Sunday Register - Oct 97 "Chariton valley group awarded $45,000 grant" "
- Ottumwa Courier - Sept 97 "Legislation includes switchgrass funding" "

ATTACHMENT 8

Secretary of Agriculture Glickman's Visit

- Iowa Farm Bureau Spokesman - Oct 97 "Iowans receive federal funds to test market biomass energy product" reprint removed
- Iowa Farmer Today - Oct 97 "Glickman likes Iowa switchgrass project" reprint removed
- Des Moines Register - Oct 97 "Glickman sees bright future for Iowa grass" "
- Ottumwa Courier - Oct 97 "Thumbs up to U.S. Secretary of Agriculture Dan Glickman "
- Ottumwa Courier - Oct 97 "Officials to tour S. Iowa switchgrass farm Friday" "
- Ad-Express and Daily Iowegian - Oct 97 "Feds to visit switchgrass project" "
- Ad-Express and Daily Iowegian - Oct 97 "Switchgrass: the future of agriculture" "
- Ottumwa Courier - Oct 97 "S. Iowa finds field of dreams" "

Pictured above: Loren Eddy (Host), Congressman Leonard Boswell, Sec of Agriculture Dan Glickman, Senator Tom Harkin, Randy Eddy (son of Loren)

reprint removed

ATTACHMENT 9

Integration of Technical Aspects of Switchgrass Production in Iowa

INTEGRATION OF TECHNICAL ASPECTS OF SWITCHGRASS PRODUCTION IN IOWA[1]

Charles Brummer[2], Lee Burras[2], Michael Duffy[3], Ken Moore[2], Mark Downing[4], and Sandy McLaughlin[4]

[2]Department of Agronomy, Iowa State University, Ames, IA 50011, USA
[3]Department of Economics, Iowa State University, Ames, IA 50011, USA
[4]Oak Ridge National Lab, PO Box 2008, Oak Ridge, TN 37831-6422, USA

ABSTRACT

As a result of the Biomass Power for Rural Development Project, which includes plans for eventual commercialization of bioenergy systems, an immediate need exists for increased and integrated research on switchgrass (*Panicum virgatum* L.) production for bioenergy. Economists, agronomists, and conversion engineers will benefit from tandem and parallel research results involving profitability, agronomic potential of switchgrass, and feedstock quality. Three research issues are important to southern Iowa: 1) the economic potential of switchgrass production to farmers who would produce it, 2) the effect of soil characteristics on switchgrass production and on ultimate yield, and 3) the effect of cultivar and germplasm variability on switchgrass productivity on marginal soils. The economic potential of switchgrass is determined by profitability relative to existing land uses. Indices of environmental quality such as rates of soil erosion, runoff characteristics, and overall soil tilth, as well as quantification of yield are major criteria in developing a management scheme or "best management at the field level" recommendations for different soil types. Ongoing and long-term breeding efforts will support the development of switchgrass with improved bioenergy characteristics adapted to the heterogeneous soils of southern Iowa. This research will help to realize the full genetic potential of switchgrass varieties. Integration of these three major research foci will clarify the potential for switchgrass as a biomass crop in southern Iowa and assist producers in making effective choices when incorporating switchgrass into their farm budgets and systems.

KEYWORDS

Switchgrass, bioenergy, agronomic characteristics, soil variability, plant breeding.

SWITCHGRASS IN SOUTHERN IOWA

The Chariton Valley in southern Iowa, U.S.A., appears ideally suited for agronomic crop production (Fig. 1). The area averages nearly 170 frost-free days and receives 32 inches (810 mm) of precipitation annually. A well-developed

[1] Research sponsored by the Office of Fuels Development and the Biomass Power Program, U.S. Department of Energy, under contract DE-AC05-96OR22464 with Lockheed Martin Energy Research Corp.

farm culture is in place, consisting of about 2500 farms, numerous agribusinesses, and knowledgeable support organizations. The main production limitation has been finding crops suitable to the soil resource. This limitation arises from the prevalence of soil consociations that are highly erosive, shallow to root-restrictive zones, and/or excessively wet. The geological strata and soils typical of the Chariton Valley are shown in Fig. 2. These characteristics make monocultures of annual grain crops ill-suited to many areas of the region, particularly because dramatic differences are common among soils within a given field. Consequently, development of a sustainable and profitable agronomic production system has been very difficult, especially during the past 40 years as farmers in the region have expanded machinery and field size.

Much of southern Iowa consists of land having erosive slopes and/or undesirable soil characteristics. Alternative cropping systems focussing on perennial crops are better suited to this landscape. One potential crop is switchgrass grown for bioenergy. Through the efforts of the Chariton Valley Resource and Conservation District (CVRC&D), the Department of Energy has invested funds to begin feasibility studies on growing and using switchgrass in southern Iowa energy plants as a replacement for coal. This project has also increased the need for research into profitable switchgrass production. Many farmers have either not grown switchgrass in the past or have grown it for livestock pasture and hay. We will address three issues in relation to switchgrass production in southern Iowa over the next several years:

1. The economic potential of switchgrass for biofuel.
2. The effect of soil and environmental variability on switchgrass production.
3. The variability of cultivars and germplasms in productivity on marginal soils.

Results from these three projects will help clarify the potential for switchgrass in southern Iowa and help producers make effective choices when attempting to integrate switchgrass into their farming systems.

ECONOMIC ANALYSIS OF SWITCHGRASS PRODUCTION

Justification

The major concern in switchgrass production is its profitability relative to existing land uses. Switchgrass production as used in the CVRC&D project will be for biomass fuel production only. Farmers are not familiar with switchgrass used for this purpose, so their acceptance of this cropping alternative will be determined primarily by its profitability. Profitability, in turn, will depend on (1) the development of practical local technology for biomass energy generation at various scales and (2) the farmers' cost of production. Clearly, the economic perspective is essential to the future success of this project.

Our research will examine switchgrass production from the farmer perspective. While other major projects are underway to study feasibility of using switchgrass in energy production, this economic study will utilize and expand the findings of these other studies to help complete the picture with respect to the desirability of switchgrass in southern Iowa relative to other potential crop uses for which markets and local production knowledge are available.

Objectives

The four specific objectives of the proposed economic analysis of switchgrass production are as follows:

1. Develop budgets reflecting on-farm costs and resource commitments for switchgrass production.

2. Estimate regional economic impacts for southern Iowa assuming a change to switchgrass production.

3. Identify, describe and document environmental and energy trade-offs of switchgrass production in southern Iowa.

Materials and methods

Budgets will be developed from case study farms in the CVRC&D Biomass Project. The farmers selected for this project will be used as the case study farms for the budgeting exercise. About 12 farms in two southern Iowa counties will be used for the Chariton Valley study. The case studies will document the operations farmers use in switchgrass production. The documentation will include the time of year at which various operations are performed, machinery used, labor requirements, fertilizer, seed, and other inputs, and other pertinent information about switchgrass production that becomes apparent during the study. The case studies will be complied to produce average budgets for a typical farm in southern Iowa.

To estimate break-even yields and prices given the costs developed in the budgets, we will use a sensitivity analysis. Actual yields in terms of both quantity and quality will be kept for the case studies. These will form the basis for the break-even sensitivity analysis.

To accomplish Objective 2, we will use the Iowa Economic/Fiscal Impact Modeling System (IE/FIMS). This model, developed at Iowa State University, helps identify and quantify city and county economic, employment, labor force, population, and fiscal impacts in response to changes in local or regional economies. A change to switchgrass production, from row crops, would be a situation well-suited to this model.

Much of the information that we will use to accomplish Objective 3 will be extrapolated from the case studies in Objective 1. The case studies will be

expanded to estimate the impact on erosion and chemical use for the fields in switchgrass as compared to alternative land uses. Some of this information will also be available from other aspects of our overall project (see below). The area of this study has a high percentage of land in the Conservation Reserve Program (CRP); therefore, environmental impacts will be estimated including the CRP option.

The main energy examination will relate to on-farm energy consumption. Energy requirements for machinery operation and for other inputs required for switchgrass production will be compared to energy needs of alternative land uses. This study will not examine the issue of energy produced from burning biomass, an objective that will be evaluated elsewhere in the Chariton Valley study. Results of this experiment will be compared with published literature focused primarily on studies with similar conditions to those in southern Iowa.

SWITCHGRASS PRODUCTION IN RELATION TO SOIL VARIABILITY AND ENVIRONMENTAL QUALITY IN THE CHARITON VALLEY

Justification

Switchgrass appears to be an agronomic crop that will succeed even with the soil limitations prevalent in the Chariton Valley. The extent of its success will be dependent, in part, on using site-specific best management practices. In particular, these practices will need to account for soil variability and potential environmental risks.

The goal of this project is to rigorously document switchgrass productivity in the context of best management at the field level. "Best management at the field level" will be evaluated based upon two criteria: (a) switchgrass productivity and (b) environmental quality. The needed management scheme is one in which the level of productivity is economically viable and the environmental quality is maintained or enhanced.

Objectives

The two objectives of the site-specific management determination are as follows:

1. Quantify switchgrass yield within selected fields according to soil consociation, landscape position, and fertility regime;

2. Quantify environmental quality changes within selected fields resulting from switchgrass production. Indices of environmental quality will consist of the following parameters: (a) rates of soil erosion, (b) runoff characteristics, and (c) overall soil tilth.

Materials and Methods

In a minimum of 16 fields throughout the Chariton Valley, determinations of the spatiality of both switchgrass yields and soil properties will be recorded. Some typical soils in southern Iowa and their production potentials for corn (*Zea mays* L.) and smooth bromegrass (*Bromus inermis* Leyss.) are described in Table 1.

Table 1: General information about some of the common soils in the Chariton Valley.

Soil	Classification[1]	Geologic Parent Material	Corn Yield (bu/ac)[1]	Smooth Bromegrass (aum)[1]
Pershing	Aquollic Hapludalf	Peorian Loess	96	5.7
Armstrong	Aquollic Hapludalf	Yarmouth-Sangamon Paleosol	59	3.1
Gara	Mollic Hapludalf	Pre-Illinioan Glacial Till	75	4.5
Olmitz	Cumulic Hapludoll	Alluvium (local)	95	5.7
Colo	Cumulic Haplaquoll	Alluvium	104	5.5
Vesser	Argiaquic Argialboll	Alluvium	95	5.0

[1] = Oelmann, D.B. 1984. Soil Survey of Monroe County, Iowa. USDA-SCS, US Government Printing Office, Washington, D.C. Abbreviations: bu/ac = bushels/acre; aum = animal unit month.

The spatiality of switchgrass yields across each field will be recorded using a standard round-baler to which has been attached a weigh bar and a Global Positioning System (GPS). The spatiality of soil consociation and landscape properties will be documented via intensive soil mapping. This soil-landscape mapping will consist of two parts: (a) conventional aerial photograph-based mapping at a 1:5,000 scale in each field and (b) statistically-based transect mapping. During mapping, field notes describing each profile's morphology (including horizonation, color, soil structure, depth to redoximorphic features, and root amounts) will be recorded. From these field notes, selected pedons will be sampled and analyzed for texture, pH, organic carbon content, cation exchange capacity (CEC), base saturation, bulk density, available water holding capacity, and moisture content.

Each field will be managed according to one of four fertility regimes: (a) native (a control having no additional fertilizers); (b) low-input (minimum recommended amounts of N, P, and K); (c) medium-input (optimal recommended amounts of N, P, and K); and (d) high-input (maximum recommended amounts of N, P, and K). All recommended amounts will be based upon conventional soil testing and recommendations provided by the ISU Soil Testing Laboratory. Although, the combination of 16 fields and four fertility regimes provides four replications of each fertility treatment, we recognize there will be differences in actual fertility rates among fields owned by different farmers, but these differing rates will

enhance the applicability of the experimental results via a quantitative evaluation on the continuum of real farming practices.

We plan to monitor the environmental quality of each field through examination of on-field and off-field changes. The two on-field parameters are (a) rates of soil erosion via sampling of visible sediment and analysis of rills and channels following storms and (b) runoff quantity and quality associated with each soil-landscape position. Additionally, overall soil tilth will be periodically assessed using standard qualitative methods. The off-field parameters to be measured are runoff quantity and quality. Off-field runoff collection sites will begin adjacent to the field. In order to better assess the actual impact of switchgrass production on environmental quality, four fields not used for switchgrass production will also be studied, two in row crop production and two in pasture.

DEVELOPING AND EVALUATING SWITCHGRASS GERMPLASM FOR BIOFUEL PRODUCTION AND ADAPTATION TO SOUTHERN IOWA

Justification

In order for switchgrass to be profitably grown for biofuel, improved cultivars incorporating high yield of feedstock material, productivity on marginal soils, and good nutrient uptake together with limited negative characteristics, such as high ash content, need to be available. Though a considerable effort toward switchgrass improvement exists at the University of Nebraska and at Oklahoma State University, the germplasm developed in the Great Plains may be of limited use in the more humid regions of south-central and southeast Iowa. Evaluation of existing cultivars will guide Iowa farmers in their selection. A breeding program focussed specifically on these areas, typified by extreme soil and weather variability, could produce varieties better suited to Iowa conditions and more profitable to farmers.

Objectives

The breeding project has two objectives:

1. Evaluate available switchgrass germplasm at two locations in southern Iowa for biofuel characteristics, and

2. Select switchgrass germplasm on good and poor sites for adaptation to southern Iowa.

Materials and methods

For objective 1, we propose to evaluate twenty cultivars and experimental populations of switchgrass at two locations in southern Iowa. The tests will be

seeded into prepared seedbeds in early April 1997 at Iowa State University's McNay Memorial Research Farm near Chariton and on CRP land that is part of the CVRC&D biomass project. *The sites will be chosen to maximize soil type and microclimatic feature differences*, providing us an understanding of genotype x environment interaction in southern Iowa. Each germplasm will be established in small plots, 10' x 15' (3 x 4.5 m) and replicated eight times. Four replications will be harvested in November; the other four will be stored "on the stump" and harvested in March the following spring.

Traits to be measured include maturity date, total dry matter yield, leaf:stem ratios based on hand separated material, and visual observations taken throughout the year. On the portion of the experiment to be stored in the field over winter, visual scores will be taken of leaf loss and standability both mid-winter and before harvest in the spring. Ash content will be determined and the ash analyzed for silicates, nitrogen, phosphorus, potassium, and pH. Additionally, acid- and neutral-detergent fiber concentration, acid detergent lignin, and total nitrogen will be measured for each sample. Leaves and stems will be analyzed independently.

In objective 2, we plan to develop two breeding nurseries, one on a good, productive site fertilized to recommended levels and a second on a nearby site with poor fertility and soil characteristics. 'Cave-in-Rock' (CIR) switchgrass, the generally recommended forage cultivar in Iowa, will be used as the base population for selection. Our selection criteria will include late maturity, plant height, steminess, low leaf disease incidence, and dry matter yield. The results of this experiment will be compared to similar studies at Oklahoma State University and the University of Nebraska.

SUMMARY

The combination of energy needs and evironmental conditions in the Chariton Valley makes switchgrass biomass production a potentially profitable and sustainable cropping system alternative. Through our evaluation of economic and agronomic aspects of switchgrass production, we hope to be able to identify farming practices, soil types, and genetic resources that will be most successfully integrated into southern Iowa.

ATTACHMENT 10

Evaluation of an Integrated Biomass Gasification/Fuel Cell Power Plant

EVALUATION OF AN INTEGRATED BIOMASS GASIFICATION/FUEL CELL POWER PLANT

JEROD SMEENK[1], GEORGE STEINFELD[2], ROBERT C. BROWN[1],
ERIC SIMPKINS[2], AND M. ROBERT DAWSON[1]

[1] Center for Coal and the Environment
280 Metals Development, Iowa State University
Ames, Iowa, USA 50011

[2] Energy Research Corporation
3 Great Pasture Road
Danbury, Connecticut, USA 06813

ABSTRACT

The Chariton Valley Biomass Power Project, sponsored by the U. S. Department of Energy Biomass Power Program, has the goal of converting switchgrass grown on marginal farmland in southern Iowa into electric power. Two energy conversion options are under evaluation: co-firing switchgrass with coal in an existing utility boiler and gasification of switchgrass for use in a carbonate fuel cell. This paper describes the second option under investigation. The gasification study includes both experimental testing in a pilot-scale gasifier and computer simulation of carbonate fuel cell performance when operated on gas derived from switchgrass. Options for a comprehensive system integration between a carbonate fuel cell and the gasification system are being evaluated. Use of waste heat from the carbonate fuel cell to maximize overall integrated plant efficiency is being examined. Existing fuel cell power plant design elements will be used, as appropriate, in the integration of the gasifier and fuel cell power plant to minimize cost complexity and risk. The gasification experiments are being performed by Iowa State University and the fuel cell evaluations are being performed by Energy Research Corporation.

KEYWORDS

Biomass Energy; Switchgrass; Gasification; Carbonate Fuel Cell; Electrical Power.

INTRODUCTION

Utilization of renewable energy sources such as biomass offers environmental benefits while providing sustainable power generation for utilities and industry. It offers markets for dedicated energy crops such as switchgrass, while providing needed energy for power generation, thereby offsetting or reducing the need for fossil fuels. In areas where fossil fuels are scarce and biomass fuels are available, biomass

utilization offers alternative low cost methods for power generation. The Chariton Valley Biomass Power Project investigates the potential of growing dedicated feedstocks as a renewable energy source.

Gasification of biomass, rather than combustion, offers efficiency, environmental, and operational advantages including the ability to use the producer gas in fuel cells. A fluidized bed gasifier, shown in Fig. 1, will be used to test the gasification of switchgrass. The producer gas composition from this gasifier will be used in a fuel cell power plant simulation study. Fuel cells convert hydrocarbon fuels to electricity at efficiencies exceeding conventional heat engine technologies while generating extremely low emissions. A proof-of-concept carbonate fuel cell power plant in Santa Clara, California, has achieved 5700 hours of operation in a grid-connected setting. The 2 MW plant, shown in Fig. 2, consists of 16 125-kW fuel cell stacks.

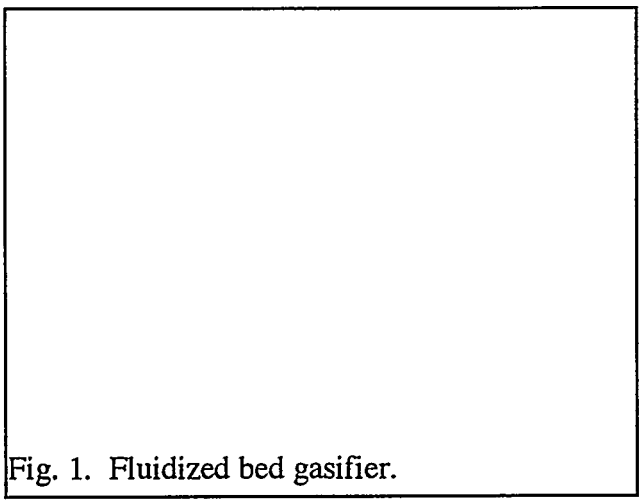


Fig. 1. Fluidized bed gasifier.

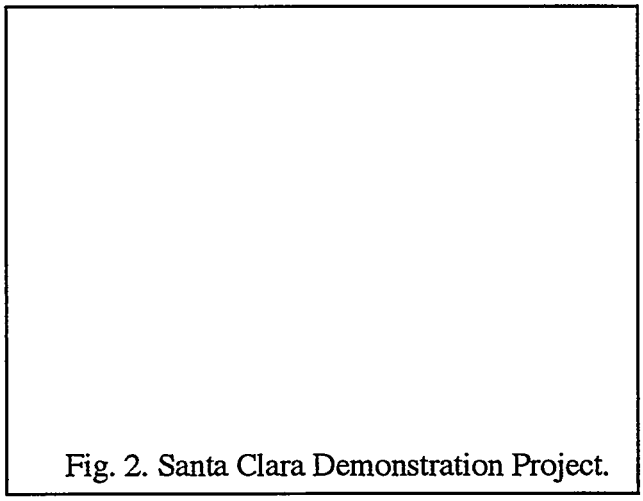


Fig. 2. Santa Clara Demonstration Project.

GASIFICATION

The fluidized bed gasifier used in this study is located at Iowa State University (ISU). A schematic of the gasifier rig is shown in Fig. 3. The air-blown gasifier operates at atmospheric pressure and is nominally rated at 2.8 MMBtu/hr thermal input. This capacity corresponds to an average feed rate of 400 lb/hr for a fuel with a higher heating value (HHV) of 7000 Btu/lb, roughly that of switchgrass. A proximate and ultimate analysis of switchgrass is found in Table 1. At the time of this writing, modifications to the material handling system were underway to enable the feeding of switchgrass. This new switchgrass feed system will consist of a bale shredder, preparation equipment, and a delivery system.

The gasifier has been instrumented to provide information concerning producer gas composition and temperature. Current gas analysis equipment consist of gas chromatographs. The gasifier is currently being equipped with a gas sampling and analysis system to quantify moisture, tars, particulates, chlorine, and alkali content in the producer gas. Additional gas analysis equipment to be added to the sampling system include a Fourier-Transform Infrared Spectrometer and the Ames Laboratory On-Line Alkali Monitor developed for the U. S. Department of Energy (DOE).

Table 1. Proximate and Ultimate Analyses of Switchgrass.

Proximate	Moisture	Volatile Matter	Ash	Fixed Carbon		
As received	8.4	73.0	4.9	13.7		
Dry	0.0	79.7	5.3	15.0		
Ultimate	**Carbon**	**Hydrogen**	**Nitrogen**	**Oxygen**	**Sulfur**	**Ash**
As received	42.9	5.6	0.5	46.0	0.1	4.9
Dry	46.8	5.1	0.6	42.1	0.1	5.3

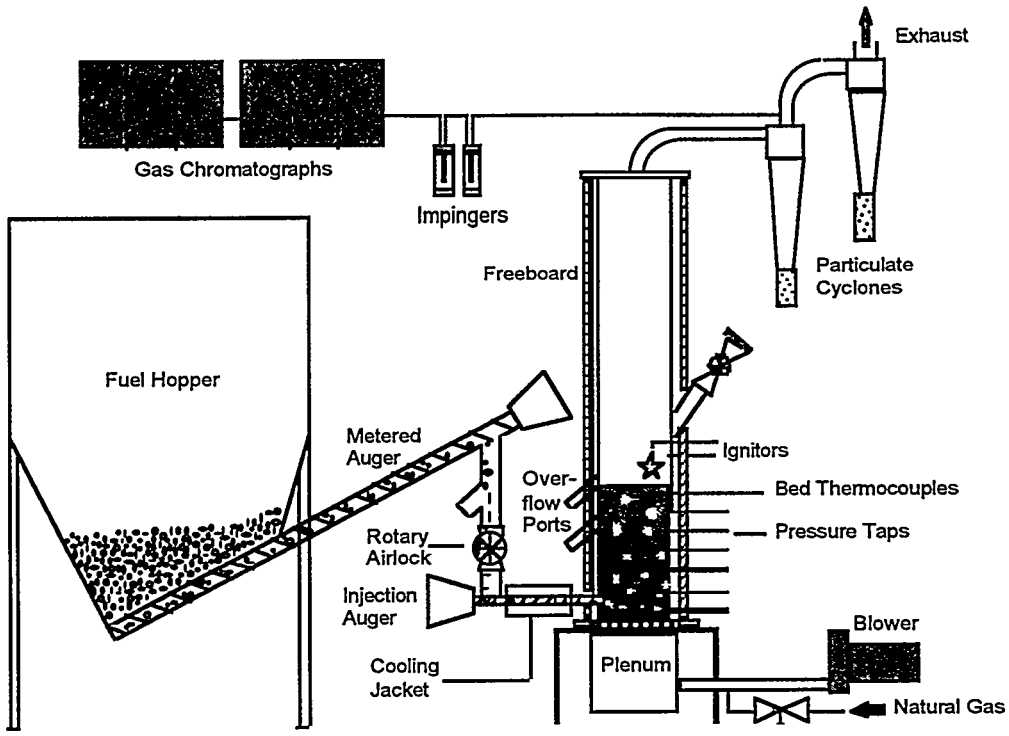


Fig. 3. Schematic of fluidized bed biomass gasification rig.

Preliminary testing of the gasifier took place with shelled corn as the feedstock. This feedstock was chosen because of its ready availability and ease of handling. Agglomeration was a significant problem in early testing. Analyses of the agglomerates revealed a sticky, viscous material high in potassium and phosphorous coated the sand particles, cementing them together in large chunks. This problem was resolved by the addition of a small fraction of limestone to the bed material.

Thermochemical conversion of biomass produces carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4), hydrogen (H_2), nitrogen (N_2), tar, fly ash, and carbon as the major constituents in the producer gas. In recent experiments the higher heating value (HHV) of the producer gas was 115 Btu/scf (standard cubic foot). Carbon conversion efficiency was determined to be 85% although tar production has not been quantified. Application of an energy balance to the fluidized bed reactor determined the cold-gas conversion efficiency to be approximately 52%.

Table 2. Compositional Analysis of Producer Gas (volumetric percent).

Carbon Monoxide	21.7%
Carbon Dioxide	12.5%
Hydrogen	4.1%
Methane	3.3%
Nitrogen	48.4%
Oxygen	0.0%
Moisture	10.0%
Total	100.0%

When the sensible heat of the exhaust gas is included, a thermal efficiency approaching 75% is achieved. Table 2 contains the composition of typical producer gas from this gasifier operating on shelled corn.

Future modifications to the gasifier rig include installation of a switchgrass handling system, a steam superheater, and additional gas analysis equipment. The steam superheater will be used to supply steam for fluidization. This steam, delivered at 1200 °F, will offset the fluidization air requirements and increase the heating value of the producer gas. Another benefit of steam addition will be increased carbon conversion. A matrix of experiments will be performed that tests the following independent variables: size of feedstock, air/fuel ratio, feedstock moisture, limestone content of gasifier bed material, fuel feed rate, and steam injection.

CARBONATE FUEL CELL

The carbonate fuel cell is an electrochemical device that converts biomass derived producer gas to electricity by electrochemical oxidation to produce water vapor and carbon dioxide as shown in Fig. 4. Biomass derived producer gas enters the anode side and air plus carbon dioxide enters the cathode side. The carbon dioxide is obtained from the anode exhaust. Due to its high operating temperature of 1200 °F, hydrocarbons in the fuel gas can be internally reformed, as illustrated in Fig. 5, utilizing waste heat, thereby improving the efficiency of the fuel cell. Fuel cell system efficiencies in the mid forties (LHV) can be achieved in this way operating on low Btu gas from switchgrass or shelled corn. Addition of a bottoming cycle to recover energy from the high temperature exhaust gases can improve efficiency further.

Development of Process Flow Diagram

The performance of a carbonate fuel cell operating on low Btu gas from an ISU air blown gasifier operating on shelled corn was estimated. Other conditions pertinent to fuel cell operation include the lower heating value, temperature, and pressure of the producer gas, determined to be 108.3 Btu/scf, 1000 °F, and atmospheric pressure, respectively.

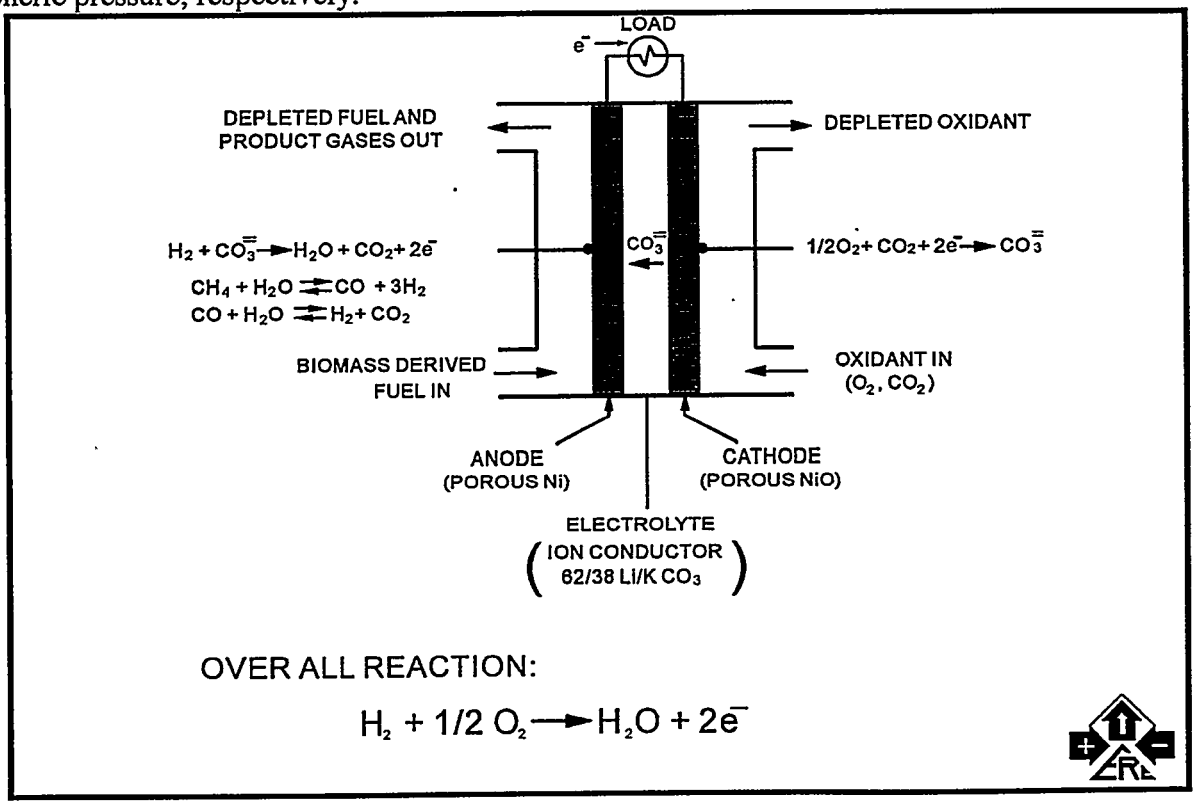


Fig. 4. Carbonate Fuel Cell System

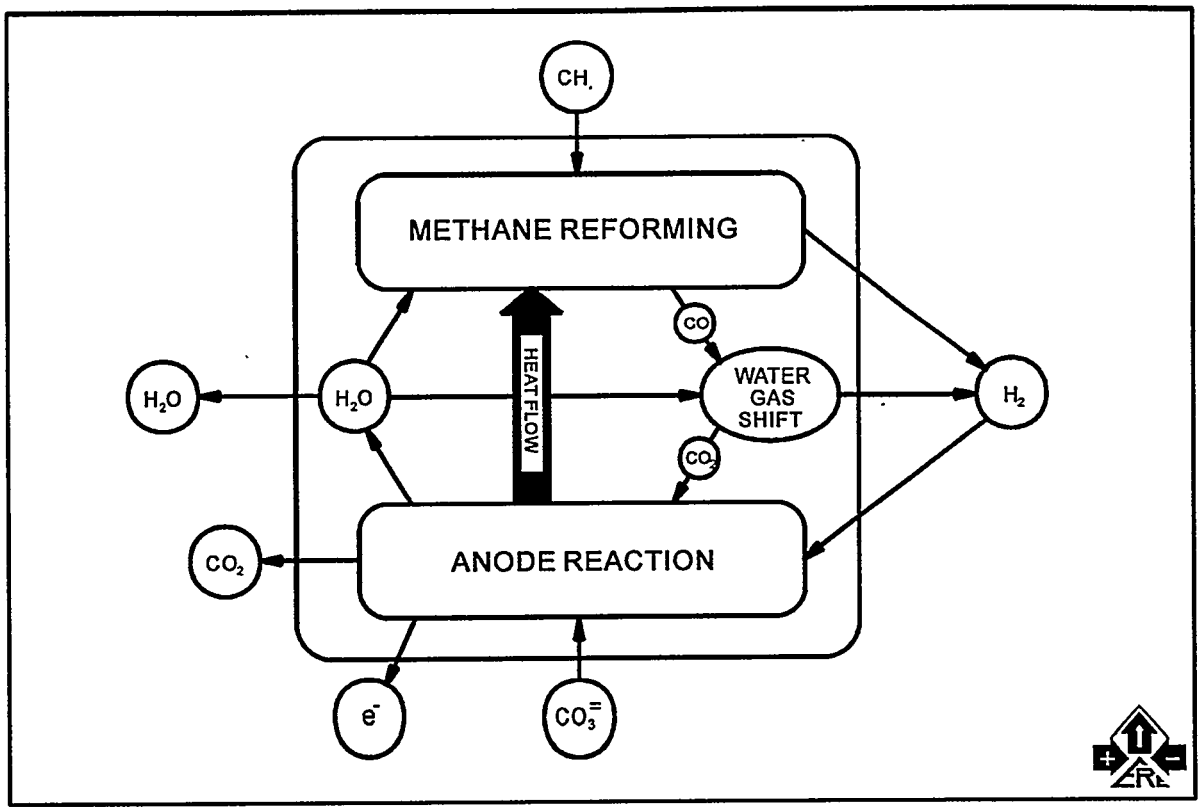
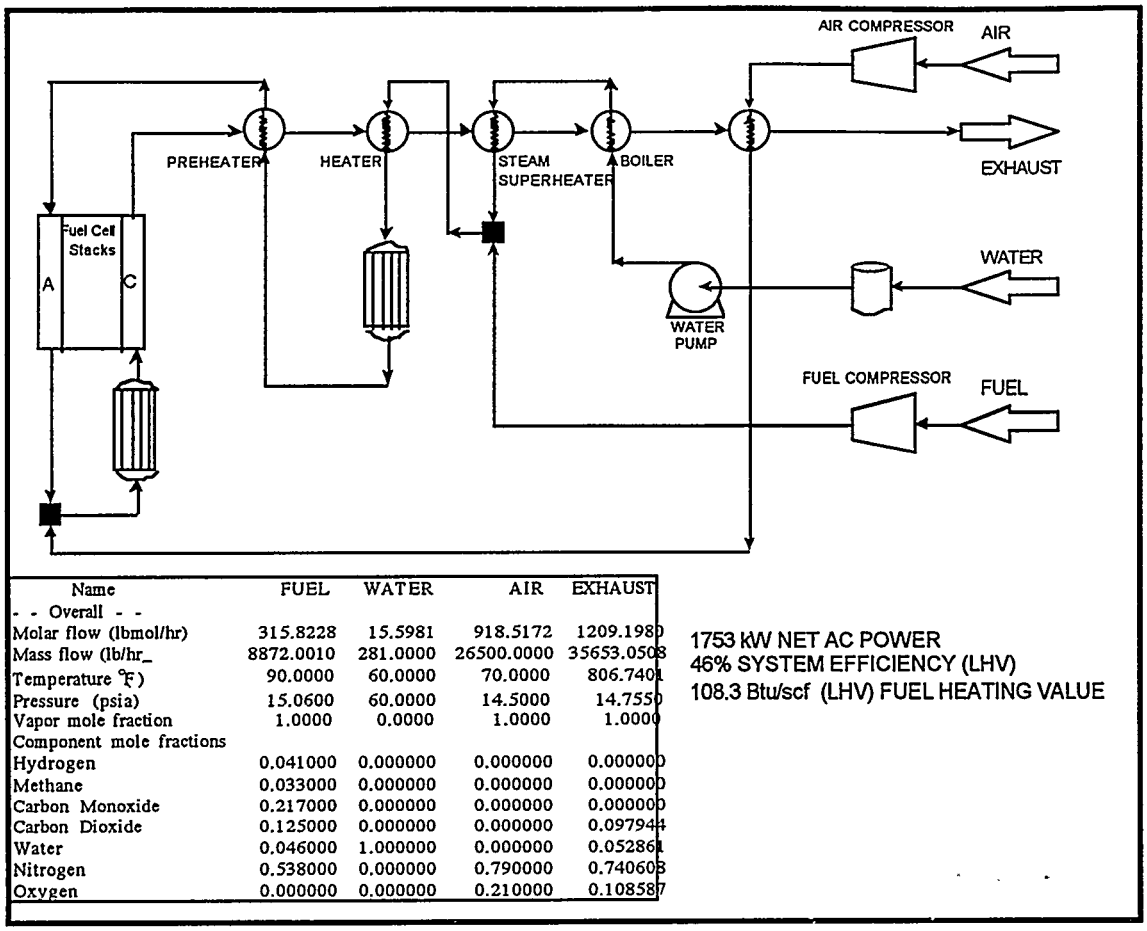


Fig. 5. Carbonate Fuel Cell Internal Reforming



Name	FUEL	WATER	AIR	EXHAUST
- - Overall - -				
Molar flow (lbmol/hr)	315.8228	15.5981	918.5172	1209.1980
Mass flow (lb/hr_	8872.0010	281.0000	26500.0000	35653.0508
Temperature °F)	90.0000	60.0000	70.0000	806.7401
Pressure (psia)	15.0600	60.0000	14.5000	14.7550
Vapor mole fraction	1.0000	0.0000	1.0000	1.0000
Component mole fractions				
Hydrogen	0.041000	0.000000	0.000000	0.000000
Methane	0.033000	0.000000	0.000000	0.000000
Carbon Monoxide	0.217000	0.000000	0.000000	0.000000
Carbon Dioxide	0.125000	0.000000	0.000000	0.097944
Water	0.046000	1.000000	0.000000	0.052861
Nitrogen	0.538000	0.000000	0.790000	0.740608
Oxygen	0.000000	0.000000	0.210000	0.108587

1753 kW NET AC POWER
46% SYSTEM EFFICIENCY (LHV)
108.3 Btu/scf (LHV) FUEL HEATING VALUE

Fig. 6. Process flow diagram for fuel cell plant operating on switchgrass producer gas.

The system and performance of the 2.85 MW direct carbonate commercial design, operating on a recent shelled corn gasification composition, is presented in Fig. 6. The 2.85 MW commercial power plant is derated to deliver approximately 1.75 MW at an efficiency of 46%. Heat recovery from the 806 °F exhaust can further improve the fuel use efficiency to 60% in large installations by including a steam bottoming cycle assuming a conservative 32% bottoming cycle efficiency and an exhaust temperature of 180 °F. In small installations the exhaust can be used to generate steam for cogeneration. Overall fuel to electricity conversion will depend on waste heat recovery and has not yet been evaluated.

Derating is necessary primarily for thermal management of the fuel cell stacks. When the plant is operated on natural gas, which is typically about 91% methane, reforming of the fuel, within the cell stack uses a large portion of the waste heat generated by the fuel cells. Fuel from the air blown gasifier has a very low (3.3%) methane content. The prereformer in the system provides both reforming and shifting but the methane content entering the reformer units within the cell stack is still only 3.7%. The result is insufficient cooling capability from the fuel stream to the cell stack. Additional cooling is provided by increasing the process air flow and limiting the temperature gradient of the air through the cells by adding an air preheater.

In this evaluation it has been assumed that there are no changes to the cell stack and burner configuration but the heat exchangers and prereformer would be redesigned to limit pressure losses at the higher mass flows.

Selection of power plant size

The power plant size depends on the logistics and economics of the gasification process and the feedstock utilized. A commercial fuel cell power plant is currently planned in the 2-3 MW range. This plant can be utilized for a biomass application in this size range. Due to the modular nature of fuel cell technology,

larger plants can be configured by multiples of the 2-3 MW plant. However, for plants larger than this size, a bottoming cycle of the full capacity of the plant may be desirable.

SUMMARY

The use of switchgrass as a dedicated energy crop is being investigated. Simulation of an integrated gasification carbonate fuel cell system results in a 1.75 MW power plant (derated from 2.85 MW) operating at 46% efficiency. Power plant output would be increased by improving the heating value of the producer gas, preferably by increasing the methane content. The effects of tars and other trace contaminants on fuel cell performance have not yet been investigated, but will be a product of this investigation.

Future work includes the installation of a switchgrass handling system, additional gas sampling and analysis equipment to identify potential trace contaminants, and a steam superheater to supply steam for fluidization to the gasifier rig. A matrix of experiments will be performed that tests the following independent variables: size of feedstock, air/fuel ratio, feedstock moisture, limestone content of gasifier bed material, fuel feed rate, and steam injection.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the Great Lakes Regional Biomass Energy Program, the Iowa Energy Center, the DOE Biomass Power Program, and the Electric Power Research Center at Iowa State University.