BIOMASS POWER FOR RURAL DEVELOPMENT

Quarterly Report for the Period
September 23 - December 31, 1996

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**CHARITON VALLEY
RESOURCE CONSERVATION & DEVELOPMENT, INC.**

Date Published - February 1997

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

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GOALS

- Tasks have been developed for Phase 1 of the project which will lead to the following goals.
- Expanded feedstock research and demonstration activities to provide soil-specific production costs and yield data, as well as, better defined methods and costs for establishment, harvest and transport.
- Four thousand acres of feedstock available for fueling a commercial venture.
- Comparison of the feasibility of both gasification and co-firing, resulting in the development plans to commercialize the technologies as appropriate.
- Designs for on-site switchgrass handling and feeding system compatible with both gasification and co-firing facilities.
- A detailed assessment of the feasibility and associated methods of using switchgrass in both gasification and co-firing situations to generate electricity using conventional turbines and fuel cells.
- A decision to proceed with commercialization.

The project has been receiving considerable media coverage in the region. Copies of some of the press clippings have been included at the end of the report. (**Appendix 1**)

The following work has been completed during the first quarter of the project ending December 31, 1996. We have attempted to identify the accomplishments as established by the original Statement of Work. (**Appendix 2**)

Important components of the project are being loaded onto an internet homepage provided by Iowa State University at <http://webbook.ameslab.gov>. (**Appendix 3**) This document as well as all participant names, addresses and e-mail addresses are, or shortly will be, available at that site.

The project has a wide range of components. We will proceed through the activities, describing each, and inserting working documents where appropriate.

1. NEPA Process

The Iowa Department of Natural Resources will begin to identify all permitting requirements and obtain necessary permitting documents and resource personnel in the next quarter.

2. Design Package Development

To avoid reinventing the wheel, our principle effort during the first quarter was to collect as much information as possible on co-firing experience to date. Task 2 co-firing activities carried out during the first quarter are identified below:

Gary Walling (I.E.S. Industries) and Conrad Anderson (R. W. Beck) attended a one-day forum on November 19, 1996, in Cincinnati entitled "Co-firing Coal and Biomass in

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Utility or Industrial Boilers" which was sponsored by the Coalition of Northeast Governors and the Northeast Regional Biomass Energy Program. Most of the discussion at this forum centered around the impact of co-firing woodwaste at utility-sized coal plants on fuel, capital, and O&M costs as well as the marketability of the flyash and bottom ash.

Conrad was asked by EPRI to attend a smaller meeting the following day to briefly describe the Chariton Valley Biomass Project to the group of utilities that sponsor EPRI's biofuels program. Detailed information was provided on a wide range of on-going biofuels projects at this EPRI-sponsored meeting.

Gary and Conrad attended a Quarterly Biomass Stakeholder Meeting at Iowa State University on December 19, 1996. The purpose of these quarterly meetings is to update stakeholders on the progress of projects underway in Iowa utilizing switchgrass as a transportation or combustion fuel. Prior to the meeting, part of the Chariton Valley Project Team discussed coordinated strategies to proceed with the co-firing and gasification tasks.

Gary and Conrad attended a brainstorming meeting with other project team members from ISU and OGS at IES's Offices in Cedar Rapids on January 10, 1997, to kick-off the preliminary design of the switchgrass handling and preparation equipment for both the co-firing and gasification options.

Gary conducted an initial investigation into the feasibility of the Chariton Valley Biomass Power Project being able to use the Section 45 Closed-Loop Biomass Tax Credit.

Conrad attempted to obtain information on the switchgrass co-firing tests conducted by MG&E in November, 1996 and its Blount Street Station in Madison, Wisconsin. (MG&E was reluctant to provide the information so Gary contacted WP&L, another participating utility in the project, and received information on the progress of that project.)

3. Establish Gasification R&D and Determine Feasibility of Establishing Small Gasification Facility

Modify fuel feeder for the pilot-plant gasifier at ISU. Attempts to modify the existing fuel feeder during the first quarter to accept chopped switchgrass were unsuccessful. These modifications included additions of agitators and different auger configurations. A meeting among project participants is scheduled for January 10 to discuss alternatives for feeding chopped switchgrass.

Prepare gas analysis system. Components of this system assembled to date include a gas cleaning train and gas chromatographs. Preliminary tests of the gas analysis system using a product gas stream from the gasification of waste seed corn yielded satisfactory compositional analysis but some operational improvements are required. In particular, GC columns showed evidence of tar deposition, which will be corrected by additional filtering provisions. Also, higher levels of moisture removal before the GCs is desirable and is being pursued. The particulate sampling system has not been assembled yet.

Prepare feedstock for gasifier. Fifteen tons of switchgrass have been obtained from the Chariton Valley RC&D, which has several acres of switchgrass under production. A tub grinder, on site at the gasifier test facility, has proved satisfactory in chopping switchgrass to desired lengths (about 2 inches).

4. Feasibility of Switchgrass Gasification Using A Relocated Gasifier

Planning for system disassembly, transport and reassembly are under way. The Iowa Alternative Energy Producers law has been under appeal to the Federal Energy Regulatory Commission by an Iowa investor owned utility (Mid America). Due to the heavy impact of the ruling on the economic viability of the project, the developers have taken a "go slow" approach.

5. Fuel Supply Plan Development

Progress report on Implementation of the Task: Switchgrass Fuel Supply Plan Development and Demonstration for Commercial Facility Startup.
2/6/96 to 12/31/96

Much of the current progress on this item can be traced to field level activities that have been going on for the last year. While the majority of specific research activities have been designed since the contract award, plot work was conducted on the RC&D area throughout last year. (Photos 1 & 2) In addition, two producers were involved with demonstrating conversion activities on CRP lands.

The major portion of this work was conducted by Alan Teel, Extension Service Agronomist for the Biomass Project. Taking advantage of the Chariton Valley RC&D access to 4,000 acres of Conservation Reserve Program (CRP) lands, approximately 1,500 acres of potential switchgrass production land was identified and scheduled for establishment in 1996 and 1997. During this period we also completed the first phase of a storage study and added another year of production data to project information. A copy is attached as **Appendix 4**. Alan has also started a series of county meetings with farmers to inform them of the project and to convince farmers to enroll some of their farmland in our switchgrass project. (Photos 3 & 4)

The first major field activity after contract award was the field day attended by project sponsors and participants. (Photos 5 & 6) The RC&D gave a project overview and John Deere demonstrated the harvest of switchgrass. This switchgrass was first cut with a forage windrower, (Photo 7) which cuts the standing switchgrass and lays the material into rows, (Photo 8) and then baled with a John Deere large square baler. (Photo 9) The baler was equipped with a modification (Photo 10) which chopped the material into approximately 6 inch lengths prior to compression in the bale. It is felt that the chopping of the material will reduce the processing necessary prior to injection into a conversion unit. (Photo 11) The material harvested at this event was loaded onto a semi trailer truck, (Photo 12) and then sent (Photo 13) to Iowa State University for use in the gasifier.

After the projects official kick off, the first step was to organize three specific feedstock development teams. One would identify and organize the producers cooperative. The second would provide technical guidance on switchgrass establishment and on conservation compliance issues related to the use of CRP lands. The third would be the research demonstration group addressing the technical issues of switchgrass production and the assembly of economic support data.

From this point the first group focused upon the recruitment of participants and the development of a producer cooperative. The local Soil and Water Conservation Districts boards, local Iowa Farm Bureau representatives and RC&D board and staff cooperatively

developed plans to organize county level meetings. This meetings would bring together prospective producers to learn more of the project with the objective of recruiting cooperative members. The first meeting was held in Wayne County in December. Three additional meetings are set for the remaining counties. This process will culminate with cooperative formation in February or March. The cooperative organization will help to focus research as well as assist in technology transfer issues. The second group is assisting with the formation of the cooperative by attending the county meetings to present information on switchgrass establishment and the aspects of using CRP land for demonstration. Their role will expand as we proceed into actual establishment.

The third group is developing plans for research design, data collection and management, and the integration of the research results with field level data to present the potential of switchgrass as a biomass crop. The following summaries represent the proposals of participating ISU staff. The group will meet in January to finalize these plans and associated responsibilities.

Economic Analysis of Switchgrass Production

Proposed by Mike Duffy, ISU Extension Economist

Recently there has been an interest in examining the potential of biomass production for energy. Several projects have been undertaken throughout the country. One area where there has been particular interest has been in southern Iowa. This effort has been led by the Chariton Valley Resource and Conservation District and Iowa State University Extension. The major crop that has been examined thus far is switchgrass.

The major concern in switchgrass production is its profitability relative to existing land uses. Switchgrass production as used here will be for biomass fuel production only. The profitability of switchgrass will determine its acceptance by farmers. Profitability will depend on development of practical local technology for biomass energy generation at various scales, and on the farmers' cost of production.

This proposed study will look at switchgrass production from the farmer perspective. There are other major projects underway examining the use of switchgrass in energy production. This economic study will utilize and expand these other studies to help complete the picture with respect to the desirability of switchgrass in southern Iowa.

Objectives

There are four specific objectives to this proposed economic analysis of switchgrass. These are:

- (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;
- (4) Produce Extension bulletins and materials detailing the findings for Objectives 1, 2 and 3.

Materials and methods:

The following discussion outlines the procedures that will be used to achieve the four stated objectives for this study.

Budgets will be developed from case study farms in the Chariton Valley RC&D Biomass Project. The farmers selected for this project will be used as the case study farms for the budgeting exercise. There are five to six farms in two southern Iowa counties that will be used for the Chariton Valley study. The case studies will document the operations performed by the farmers in switchgrass production. The documentation will include the time of year, machinery used, labor requirements, inputs used and other pertinent information surrounding switchgrass. **(Appendix 5)** The case studies will be compiled to produce average budgets for a typical farm in southern Iowa. Data for the budgets will come from the case studies. In the event operations are not performed by the individual farmers, economic engineering will be used to reflect the situations for individual farms.

A sensitivity analysis will be used to estimate break-even yields and prices given the costs developed in the budgets. 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 the Iowa Economic/Fiscal Impact Modeling System (IE/FIMS) will be used. This model was developed at Iowa State University. The purpose of IE/FIMS is to help 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 would represent such a change in the economy. IE/FIMS produces a series of reports in stages. For this project the IE/FIMS would be used only to provide an economic assessment of the change to switchgrass production. This assessment would include an estimate of the total area economic impacts using a standard Input-Out economic impact model. The estimates include employment and general level of economic activity in the region.

Certain assumptions will be necessary to utilize IE/FIMS. These assumptions include the acreage and level of production of switchgrass, the individual farm profitability of switchgrass, the change in land use for acres going into switchgrass, and how this changes from current land use profitability. The assumptions will be made in consultation with the experts on switchgrass production and its potential in southern Iowa. Several runs of IE/FIMS will be made to determine the sensitivity of the impact estimates to changes in the assumptions.

Several sources of information will be used to accomplish Objective 3. Much of the information 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. The area of this study has a high percentage of land in the Conservation Reserve Program. Environmental impacts will be estimated including the CRP option.

The main energy examination will be on-farm. Switchgrass production energy consumption for machinery operation and inputs will be compared to alternative land uses. Energy in terms of the output will be evaluated in other parts of the Chariton Valley study.

Additionally, a literature review of biomass production will be produced to help accomplish Objective 3. This literature review will focus primarily on studies relating to conditions similar to those found in southern Iowa.

Results from Objectives 1, 2, and 3 will be presented in Extension publications. At this time it is not possible to say how many publications would result but at least two will be produced. One will be a standard budget similar to the Iowa State Extension Publication FM1712, "Estimated Costs of Crop Production in Iowa". This may be produced as one of a series of CRP fact sheets that are developed by Iowa State University Extension. The second publication will be a more generic Extension publication looking at the whole issue of biomass production and its impacts on southern Iowa. This will include the information obtained in all of the Objectives. Other publications would be possible depending on the results of the research in this and the other related projects.

Switchgrass Production in Relation to Soil Variability and Environmental Quality in the Chariton Valley, Iowa Area.

Lee Burras and Ken Moore, Department of Agronomy, Iowa State University.
October 23, 1996

Introduction

The Chariton Valley area appears ideally suited for agronomic crop production. The average frost-free season and precipitation are nearly 170 days and 32 inches, respectively. A well developed farm culture is in place. It consists of about 2,500 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. Furthermore, dramatic differences are common among soils within a given field. Consequently, development of a sustainable, profitable agronomic production scheme has been very difficult, especially over the last 40 years as the farmers in the valley have expanded machinery and field size.

Switchgrass (*Panicum virgatum*, L) appears to be a an agronomic crop which will succeed even with the soil limitations. The extent of its success will be, in part, dependent on using site-specific best management practices. These practices will especially need to account for soil variability and likely environmental risks.

The goal of this project is simply 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 where the level of productivity is economically viable while simultaneously environmental quality is maintained or enhanced.

Objectives

- (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: (a) rates of soil erosion, (b) runoff characteristics, and, (c) overall soil tilth.

Abbreviated Experiment Design

A minimum of 16 fields will be studied. The spatiality of switchgrass yields across each field will be recorded using a weighing baler fitted with a 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 kept. From these field notes, selected pedons will be sampled and analyzed for texture, pH, organic carbon content, CEC, base saturation, bulk density, available water holding capacity, and moisture content.

Each field will be managed according to one of four fertility regimes. These regimes will be: (a) native (i.e., control having no additional fertilizers); (b) low-input (i.e., minimum recommended amounts of N, P, and K); (c) medium-input (i.e., optimal recommended amounts of N, P, and K); and, (d) high-input (i.e., 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, it is recognized there will be differences in actual fertility rates applied between fields owned by different farmers. Fortunately, these differing rates will enhance the applicability of the experimental results via a quantitative evaluation of the continuum of real farming practices.

The environmental quality of each field will be monitored via examination of on-field and off-field changes. Two on-field parameters to be measured 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 single off-field parameter to be measured is runoff quantity and quality. Off-field runoff collection sites will begin adjacent to the field. Off-field runoff assessment will be identical to the on-farm runoff. 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 of these fields will be used for row crop production and two of these fields will be used as pasture.

Expected Results and Conclusion

It is projected that about ten significant soil-landscape units will be identified. For the most part these will match existing soil map units recognized by the Soil Survey division within the USDA-NRCS. It is expected each unit will have a unique response to the differing fertility regimes but that in general increased fertility will result in improved productivity. More importantly, it is expected that each soil-landscape unit will be economically productive, provided farmers apply unit-specific best management practices. Finally, it is projected that switchgrass production in general will be shown to be much more environmentally suited to the Chariton Valley than row crop and marginally better than pasture.

Developing Iowa Adapted Switchgrass Varieties For Biofuel Production

E.C. Brummer and K. Moore, Iowa State University, Agronomy Department

Little switchgrass breeding work has been conducted in the upper Midwest, particularly in developing varieties as biofuels. Though a considerable effort toward switchgrass improvement exists at the University of Nebraska, most of the germplasm developed in the more arid Great Plains is of limited use in south-central and southeast Iowa. A breeding program focused specifically on these areas typified by extreme soil and weather variability would produce varieties better suited to Iowa producers. We propose a dual track approach for the development of switchgrass with improved biofuel characteristics.

Project 1: Evaluation of available switchgrass varieties at two locations in southern Iowa.

We propose to evaluate fourteen varieties of switchgrass for various biofuel traits at two locations in southern Iowa. Two additional experimental germplasms we have developed will be included if sufficient seed is available. The tests will be seeded into prepared seedbeds in early April 1997 at the McNay Research Farm of ISU near Chariton and on CRP land that is part of the Chariton Valley RC&D biomass project. The sites will be chosen to maximize soil type and microclimatic feature differences to provide a better understanding of how these varieties will be expected to produce in southern Iowa. Weeds will be controlled with atrazine. The main focus of this project is to assess varietal growth and development rather than establishment so every effort will be made to ensure a successful stand of all varieties. Each variety will be established in small plots, approximately 3' x 20'. Each variety will be replicated eight times. Four replications will be harvested in the fall; the other two will be stored "on the stump" and harvested 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. On all materials, caloric content of the herbage will be measured by bomb calorimetry. Ash content will be determined and the ash analyzed for silicates and other constituents, such as nitrogen, and pH. Leaves and stems will be analyzed independently. Experimental data will be taken for at least two years.

Project 2: Development of a switchgrass breeding nursery to select for biofuel traits.

'Cave-in-Rock' [CIR] switchgrass is generally recommended within Iowa as the best forage variety because it produces high dry matter yields. Until the results of Project 1 are available to identify other superior varieties, we plan to begin selection within CIR for the various traits identified above. Two thousand seedlings of CIR switchgrass will be transplanted from the greenhouse to the McNay Research Farm in late spring 1997. Spacing between plants will be 1 m within and between rows. Visual scores for vigor, leafiness, height, and maturity will be taken throughout the year in 1997 and 1998. Plants will be allowed to stand over winter and scores of standability and leaf loss will be determined. Additionally, tissue samples will be taken for laboratory analyses both in fall and spring. Superior plants will be selected in spring 1999 and intercrossed to form the first cycle of selection for biofuel traits. This project is the beginning of a long-term selection program to develop varieties adapted to southern Iowa.

The results of these projects will help clarify the variation present in existing germplasm for traits important to energy production. Improved populations of CIR will be tested as potential varieties. Future breeding work will incorporate the most promising populations identified by the varietal evaluation project.

6. Project and Performance/Guarantees and Warrantees

No activity at present

7. Construction and Environmental Permits

No activity at present.

8. Environmental Analysis Planning

The primary focus for environmental assessment activities to date has been the identification of available data and development of Geographic Information Systems data layers. To date, the project staff has assembled all of the layers of available state and regional significance. This includes soils information with field level accuracy, major streams, roads, and civil boundaries. In direct support of this project we have established the locations of all Conservation Reserve Program contracts in the four county area. This contract information includes the date of the contract owner information, type of current ground cover and specific field size and boundaries.

This CRP information has been digitized, that is the location is spatially referenced to the other GIS data. Layers can then be compared by different variables such as soil type and productivity versus distance for transport and collection. The information can also be crossed referenced to current land use to predict the soil and water conservation effects of land use changes, i.e. increases in energy crops or decreases in CRP acres.

Ultimately this information will be used as the basis for soil and water impact assessments for the project and specifically as they apply to the Rathbun Watershed. The boundaries of the watershed have also been digitized which will allow us to identify CRP lands that also drain to the lake.

To compliment this GIS analysis, site work is scheduled in conjunction with yield and management research. This work will address soil fertility and erosion factors at the micro level and will supply information to support modeling assumptions. The following two pages show maps generated with the developed data layers. The first shows the boundary of the Rathbun Lake watershed in relation to the cities and counties in the Chariton Valley area. The second displays the locations of the identified CRP tracts in one of the Chariton Valley Counties.

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RATHBUN LAKE WAT

Source: Iowa DNR Digital Data
Chariton Valley RC&D

ERSHED

LEGEND

- County Boundaries
- Water Impoundment
- Cities
- Roads
- Major Streams
- Rathbun Lake Watershed

1 0 1 2 3 4 5 Miles

A scale bar with alternating black and white segments, representing distances from 0 to 5 miles.

LUCAS COUNTY CRP

Source: Iowa DNR Digital Data
USDA Natural Resources Conservation Service

LEGEND

- County Boundary
- Major Roads
- Lucas County Roads
- Major Streams
- Cities
- Lucas County CRP (Dec. 1994)
- Lake Rathbun Watershed Boundary

PHOTO #1: Growing Switchgrass

PHOTO #2: Winter Switchgrass

PHOTO #3: County Meeting Site

PHOTO #4: County Meeting

PHOTO #5: Field Day Participants

PHOTO #6: Field Day Participants

PHOTO #7: Mower/Conditioner

PHOTO #8: Wind Rows Of Switchgrass

PHOTO #9: Baling Switchgrass Into Large Square Bales

PHOTO #10: Material Chopped Before Compressed Into Bale

PHOTO #11: Broken Bale of Switchgrass

PHOTO #12: Loading Bales On Semi Trailer

PHOTO #13: Semi Trailer Loaded With Square Bales

APPENDIX ONE

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Oct 14, 1996

THE REGISTER'S EDITORIALS

Iowa's new cash crop?

Switchgrass mixed with coal could be the best thing since ethanol.

A new cash crop for Iowa? How about electricity?

Federal energy and agriculture officials are putting \$2 million into a southern Iowa grass-to-electricity project, with the possibility of \$8 million more to come. That would be matched by contributions from Chariton Valley Resource Conservation and Development, IES Utilities, and the Iowa Departments of Agriculture and Natural Resources.

The money will pay the bills for an experiment in mixing a little switchgrass in with the coal burned in the generation of electricity at the IES Utilities' Eddyville plant. There are all kinds of reasons burning grass to produce electricity makes environmental sense. The experiment will help show whether it also makes economic sense — or how close it comes.

The test, to be supervised by the Chariton agency, could provide the most significant shot in the arm to Iowa's energy-production effort since the push to sell ethanol. Alternate-energy authorities have long viewed the biomass-burning potential as huge.

The primary interest of promoters is developing a new cash crop, said Jim Cooper, coordinator for Chariton Valley Resource Conservation and Development. Growing switchgrass is easy; it's a long-lived perennial and thrives best with a shot of nitrogen fertilizer. Questions yet to be answered are how best to harvest the grass and how best to chip it into one-inch lengths for complete burning in the coal furnaces.

Biomass burning, particularly switchgrass burning, has lots going for it besides being a fuel that will grow right outside the door of the generating plant. In the first place, Iowa has lots of land unsuited for row crops but suitable for forage grasses.

Second, switchgrass is the best candidate because it's a perennial that grows fast, and loves Iowa soil.

Third, switchgrass grown on CRP (federal conservation reserve program) land can be harvested yearly without diminishing its functions of holding the soil well and providing wildlife cover. And since it is to be burned rather than fed to livestock, it can be harvested for fuel and still meet the CRP criteria of taking the land out of agricultural production.

In the initial generating experiments, the coal-grass mixture will be about 20-to-1. IES Utilities will get a tax credit for using biomass fuels that will help offset any extra cost involved in the coal-grass mixture.

Environmentally, switchgrass beats coal every which way. Carbon in both fuels is converted to carbon dioxide; the heat from the process generates electricity and the CO₂ enters the atmosphere. CO₂ from any source is a greenhouse gas and potential pollutant. The difference is that burning coal adds to the total atmospheric carbon content because it releases carbon that is otherwise stored away deep below the Earth's surface. Burning grass simply releases CO₂ that the plant took out of the air while growing.

Burning coal releases sulfur dioxide, particulates and some hazardous trace metals

in far greater quantity than burning grass. The ash from a coal plant can be a hazardous waste; the ash from grass burning can be sold as fertilizer.

The same advantages accrue to burning hybrid trees, a process under study for years at Iowa State University using hybrid aspens and poplars.

Then there are the costly drawbacks. While coal fouls the air, it fouls the furnace less than grass. Iowa State University engineer Robert Brown, director of the Center for Coal in the Environment, said potassium compounds released in the burning of grasses clog up the furnaces. Further, while grass may be economically competitive with coal on a pound-for-pound basis (meaning it generates about the same heat), it takes a far greater volume of grass to make a pound. That adds expense, particularly in transportation.

Iowa's energy bill is astronomical, and almost all of the money goes out of state. The oft-quoted statistic has Iowa paying \$5 billion yearly for energy. Half of that goes for the oil that fuels transportation. Of the rest, \$364 million goes for imported coal to be burned to produce electricity. Shifting a fraction of that to grass could mean a lot to the Iowa economy.

There are technical problems to be resolved, high among them the potassium clogging. It's possible that the best technology may not make grass competitive with coal unless the damage done by the pollution caused by burning coal is taken into account. That raises other problems: Measuring that damage, and putting an accurate price tag on it.

The reality of that pollution must someday be acknowledged. The sooner it is, the better the prospect looks for reaping profits from Iowa switchgrass.

The switchgrass drawing is by Shirley Shirley of Eldora, author of "Restoring the Tallgrass Prairie" (University of Iowa Press, 1994). In her book she describes the prairie perennial as an aggressive Iowa native that grows as high as 7 feet tall. The fruit ripens in late summer. It's a staple in the diet of birds, butterflies and browsing animals. Wildlife managers love it because it provides excellent cover and a quick stand. Also, it develops a deep root system for erosion control.

Is switchgrass fuel for the future?

Research under way in S. Iowa

By **ALAN PIERCE**
Southern Iowa editor

MORAVIA — Miners used to dig for coal in Appanoose, Monroe, Lucas and Wayne counties. But now a team of economic development, energy and ag officials hope farmers in those counties can grow coal — coal in the form of switchgrass.

The Chariton Valley Biomass Power project is exploring the possibility of co-firing switchgrass with coal to use in power plants. The project also is working to develop switchgrass into feedstock.

"The potential is what we're excited about," Jim Cooper, Chariton Valley RC&D coordinator, told a

group at a switchgrass demonstration Thursday near Rathbun Lake.

Cooper said IES Utilities is interested in how switchgrass can be used at its plant near Chillicothe.

IES Utilities, Iowa State University and other industries are working to develop technology to convert agricultural crops to energy. According to Chariton Valley, the long-term plan calls for a power plant that would require 30,000 to 40,000 acres of crops.

Representatives from the agencies involved in the project and farmers watched the grass being cut and baled.

Chariton Valley has conducted field level demonstrations using about 300 acres of switchgrass. The U.S. Department of Agriculture

Farm Service Agency has agreed to allow development on 4,000 acres of Southern Iowa CRP land, Chariton Valley said in a news release.

Cooper said there is local concern about the future of acres enrolled in the Conservation Reserve Program.

"We know eventually it will end," Cooper said about CRP.

Those involved in the project think those acres could be used to raise switchgrass.

It's a long way from the grand designs envisioned by those in the project, but Alan Teel said pellets made from switchgrass were being used to fuel a heater at a machine shop in Moravia.

"I don't think there's anybody else burning switchgrass," said Teel, field coordinator for the switchgrass biomass to energy project.

Alan Pierce/The Courier

Jim Cooper, Chariton Valley RC&D coordinator, discusses a switchgrass project Thursday north of Rathbun Lake. Cooper said companies are interested in using switchgrass with coal in power plants.

Farmers to harvest 2 new crops: Switchgrass, then electric power

The southern-Iowa project is a cooperative effort of government, utilities and the private sector.

By JANE NORMAN

OF THE REGISTER'S WASHINGTON BUREAU

Washington, D.C. — Southern Iowa farmers will be encouraged to grow switchgrass on marginal farmland as part of a \$20 million project to use the crop as fuel to generate electricity, federal officials announced Wednesday.

In a conference call with Iowa reporters, Sen. Tom Harkin, D-Ia., and Energy Secretary Hazel O'Leary said the Department of Energy will provide \$6 million and the Department of Agriculture \$4 million in a federal-local-private partnership over four years.

The remaining \$10 million will come in the form of cash and in-kind contributions from several sources, including IES Utilities; Iowa State University; Chariton Valley Resource, Conservation and Development; the Iowa Division of Soil Con-

servation; and the Iowa Department of Natural Resources.

As many as 500 farmers in the Lake Rathbun watershed will take part in the project, officials said, tilling an estimated 30,000 to 40,000 acres of underused land now used for other crops or placed in the Conservation Reserve Program.

Switchgrass would sell for \$40 to \$50 a ton, and at five tons an acre a farmer would get \$200 to \$250 an acre, Harkin said, offset by production costs, which are lower than for traditional crops.

Once farmers harvest the switchgrass in late fall, it will be taken to a coal-fired generator south of Eddyville owned by IES Utilities, where it will be combined with coal to produce electricity. Officials said they aim to reduce by 5 percent the amount of coal now used there.

IES also will receive a federal tax credit of 1.5 cents per kilowatt for its use of switchgrass.

"What ethanol is to gasoline, switchgrass can be to electric power," Harkin said. "So I would call this the ethanol of electricity."

Switchgrass, a perennial, is the kind of grass that covered Iowa when pioneers arrived in the 1800s,

said Jim Cooper of the Chariton Valley organization, a rural development operation whose staff members' salaries are paid by the USDA.

The hardy, low-maintenance grass is often used by the Iowa Department of Transportation for roadside plantings.

On CRP land, it would serve to reduce erosion and create wildlife habitat.

The announcement of the project came less than five weeks before voters go to the polls to decide whether to re-elect both Harkin and President Clinton.

Monte Shaw, a spokesman for Harkin's Republican opponent, Rep. Jim Ross Lightfoot, said Lightfoot didn't have detailed information on the initiative. But Shaw said "it sounds like a program of good benefit to Iowa farmers and the economy. . . . I think he would be in full support of it."

Harkin said 98 percent of Iowa's energy comes from outside the state, at a cost of about \$5 billion a year, and the switchgrass project could pave the way for other utility plants to use the grass for fuel. More than \$5 million also could be pumped into the Iowa economy, Harkin said.

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Southern Iowa to get switchgrass project

By PATSY CINCOTTA
Staff Writer

Sen. Tom Harkin announced Wednesday that southern Iowa will receive a cooperative agreement between the Departments of Energy and Agriculture. The award, said to be worth \$20,000,000 to Iowa, will be for the growing and harvesting of switchgrass as an inexpensive source of energy.

Switchgrass, a perennial grass Harkin described as "something all pheasant hunters like me have probably cursed because it grows so tall,"

will be baled, driven to the IES coal plant in Ottumwa and mixed with coal when it's burned for energy. It is planned that the grass will represent about 5 percent of the plant's energy output, which produces 740 megawatts of energy.

Harkin called Jim Cooper of the Chariton Valley RC&D the real leader of the project and said he and Cooper had been working on this plan for about three years.

"Not only will this provide farmers in southern Iowa who have marginal farm land a new income stream, this project may lead to some more manufacturing in the area," said

"Not only will this provide farmers in southern Iowa who have marginal farm land a new income stream, this project may lead to some more manufacturing in the area."

-- Sen. Tom Harkin

Harkin. "It may lead to a lot of other projects. It is something that hasn't been tried before and we don't know what all might be involved.

"An acre of switchgrass is worth \$200 to \$250 with low production

costs. If 80 acres are planted, that's around \$16,000. The grass is a perennial so it grows each year without being re-planted. And it grows fast. The farmer can plant in the spring and harvest in the fall."

The project calls for up to 500 farmers participating and, according to Harkin, anyone interested in being in the project should call Jim Cooper. There will be some educational programs offered to farmers getting into growing switchgrass and these will be given through the RC&D office. The initial program will be concentrated in southern Iowa through the Chariton Valley RC&D office and will start next year. The project will run for the next four to six years.

Harkin said IES Utilities and the University of Iowa are both playing big roles in the program.

"There are probably 30,000 to

40,000 acres of marginal farm land in Iowa which are not being utilized like they could be under this plan," added Harkin. "This could pave the way for thousands of farmers. It would be home grown energy produced by local farmers. Using highly erodible land we can develop an energy source which helps reduce dependence on fossil fuels, and at the same time helps southern Iowa farmers grow new opportunities.

"I'm really excited and pleased I can make this announcement. This is what's really needed in southern Iowa, a way to increase farm income," Harkin said.

Biomass research area near Honey Creek Park

Farmers hope to one day benefit from biomass project

Years and years ago, the same guy who thought of raising elk as a meat animal got excited about raising a grass product on southern Iowa hillsides that could be harvested like hay, but sold like coal or oil.

Chuck McCarty, the long-time head of the Chariton Valley Resource and Development Corp. (RC&D), died before his dream became close to a reality, but his successor, Jim Cooper, may well see the biomass project turn into something exciting for farmers in this part of the state.

The federal government has approved an appropriation of \$20 million to study the feasibility of raising switchgrass, not to feed cows, but to feed coal generators. Last month the federal government announced that \$6 million would come from the Department of Energy, \$4 million would be raised from federal-local-private partnership funds over four years and another \$10 million will come in the form of cash and in-kind contributions from several sources including IES Utilities, Iowa State University, Chariton Valley RC&D, the Iowa Department of Natural Resources and the Iowa Division of Soil Conservation.

As many as 500 farmers in the Lake Rathbun watershed will take part in the project, putting up to 40,000 acres of underused land, now used for other crops or in the Conservation Reserve Program, into

switchgrass.

The switchgrass will be harvested in late fall, using big round balers to bale it, then it will be taken to the coal-fired generator south of Edyville owned by IES Utilities where it will be combined with coal to produce electricity. The plan is to reduce by five percent the amount of coal now used there.

IES, in return, gets a federal tax credit of 1.5 cents per kilowatt for its use of switchgrass.

The switchgrass will be sold for \$40 to \$50 per ton to IES from farmers. If they can pull at least five tons an acre off their fields, that means a \$200 to \$250 gross for farmers. Since inputs are far lower than traditional crops, growing switchgrass could be very prof-

itable for farmers and extremely friendly to highly erodible southern Iowa hills.

The switchgrass also makes ideal habitat for wildlife, according to DNR wildlife biologists.

"What ethanol is to gasoline, switchgrass can be to electric power," said Iowa Sen. Tom Harkin, one of the backers of the program.

Switchgrass is a perennial and is what covered Iowa when pioneers used single bottom plow and oxen to cut through the prairie. It is a hardy, low-maintenance grass often used by the Iowa Department of Transportation for roadside plantings.

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THE OTTUMWA COURIER

Thursday, Oct. 3, 1996

Southern Iowa's Best Newspaper

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Feds fund Southern Iowa ag project

\$10 million program allows farmers to grow switchgrass, sell it for fuel

DES MOINES (AP) — Up to 40,000 acres of marginal crop land in Southern Iowa could be turned to switchgrass production under an alternative energy plan that won federal funding Wednesday.

The Department of Energy is contributing \$6 million to the project and the Department of Agriculture is adding up to \$4 million, U.S. Sen. Tom Harkin, D-Iowa, announced.

Up to 500 farmers would grow a total of up to 200 tons of switchgrass annually and sell

it for fuel at \$40-\$50 a ton, Harkin said. It would be burned with coal at an IES Industries Inc. plant near Eddyville, displacing about 5 percent of the coal now burned at the plant.

Harkin likened the project to the development of corn-based ethanol, which is mixed with gasoline.

"What ethanol is to gasoline, switchgrass can be to electric power," Harkin said. "I think this has the potential 10 years from

now of involving thousands and thousands of Iowa farmers."

"This is great for the farm economy," U.S. Energy Secretary Hazel O'Leary said. The Department of Energy has funded similar biomass projects in Minnesota, New York and Vermont, she said.

The project makes sense in Southern Iowa because much of the crop land is poor and the region imports its energy, said Jim

Cooper of the Chariton Valley Resource Conservation and Development district, which is coordinating the project.

"We're very excited about the possibility of getting an energy crop industry started in Southern Iowa," Cooper said. "We have lands that are much less suited to row crops."

Cooper said that switchgrass, a perennial plant that is native to Iowa, is well suited for

energy production.

"It's a tall-growing grass. It has an extensive root system," he said. "Coal and switchgrass are very equivalent in heating value per ton."

The project is expected to be in full operation by 2002, O'Leary said. IES will get a 1.5 cent tax credit for each kilowatt hour produced by burning switchgrass at the plant, Harkin said.

OPINION

The Des Moines Register

A GANNETT NEWSPAPER

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THE REGISTER'S EDITORIALS

THE REGISTER'S READERS SAY

Switchgrass won't replace coal as fuel

Your Oct. 14 editorial touted the use of switchgrass to replace a portion of the coal used to fuel electric-utility generators because "environmentally, switchgrass beats coal every which way."

You might be interested to know that there are at least some reasons why such a fuel alternative may not make as much sense environmentally as it would seem to make.

It is highly unlikely that switchgrass or any other biosolid could ever become the majority of the fuel burned in the utility plants of Iowa. The mechanism for handling, stockpiling and feeding the material is hugely different from coal handling. Burning wet coal can be problematic for utility companies at times, but coal is far less absorbant than switchgrass. A stockpile of switchgrass large enough to make a significant contribution to the fuel

needs of a plant that burns 40,000 tons of coal per week (such as IES's Ottumwa Generating Station) could become a saturated, unburnable, rotting mass in a hurry.

Using switchgrass for a minor fuel constituent means that the resultant coal/grass ash produced may not be suitable for "fertilizer," as you mentioned as an environmental benefit, because combustion leads to the loss of nitrogen and phosphorous as gaseous emissions that are not maintained in the ash.

When ethanol was touted as a fuel for cars and trucks, many claims were made regarding environmental advantages, higher octane ratings, etc. There is one glaring problem that has not been addressed regarding the increasing percentage of it in the motor fuel: In order to make the ethanol blend appealing to the customer, a portion of

the road-use tax has had to be deferred. If the motorist had to pay the true cost for the ethanol inclusion, he or she would not purchase it.

As a result of this "environmental bribe," the road-use tax fund has lost tens of millions of dollars in revenue that could have been available for road and bridge improvements. Are there any "hidden pitfalls" of this variety involved in the use of switchgrass as a coal replacement?

Before enticing the people of Iowa to jump on the switchgrass bandwagon, it might be good to provide an in-depth analysis of all of the ramifications relating to this option.

— **Lon Zimmerman, president,**
Midwest Fly Ash and Materials Inc.,
2220 Hawkeye Dr., Sioux City.

APPENDIX TWO

STATEMENT OF WORK

CHARITON VALLEY RC&D, INC.
STATEMENT OF WORK

The objective of the Chariton Valley Biomass Power project is the development of markets for energy crops in southern Iowa. According to the Black and Veatch feasibility study completed over one year ago, co-firing switchgrass with coal in an existing facility was a very practical method to develop this market. However, the potential of developing a gasification option has surfaced and caused modifications to our original approach to increase flexibility and allow pursuit of both technologies. From our perspective the type of technology is a means to reach our objective to develop a reliable and cost effective feedstock supply based upon southern Iowa forages.

At the completion of Phase I we will have

- Expanded feedstock research and demonstration activities to provide soil-specific production costs and yield data, as well as, better defined methods and costs for establishment, harvest and transport.
- Four thousand acres of feedstock available for fueling a commercial venture.
- Compared the feasibility of both gasification and co-firing, resulting in the development plans to commercialize the technologies as appropriate.
- Designs for on-site switchgrass handling and feeding system compatible with both gasification and co-firing facilities.
- A detailed assessment of the feasibility and associated methods of using switchgrass in both gasification and co-firing situations to generate electricity using conventional turbines and fuel cells
- A decision to proceed with commercialization.

The following statement of work addresses these issues and supports the requested Phase I funding.

CHARITON VALLEY RC&D, INC.

Statement of Work

1. NEPA Process

Required actions will be determined in consultation with the Department of Energy. Technical assistance and review will be provided by Iowa DNR.

Completion will be determined by discussion with DOE

2. Design Package Development for Co-firing Option

We will investigate further the details of a commercial co-firing project with IES to include the design of co-firing modifications. Using the results of co-firing tests and the fuel handling system designs, IES will be presented with sufficient information to make a decision to proceed with the co-firing project at OGS.. Phase I costs include the detailed engineering for co-firing modifications as well as the project costs for the co-fire testing procedures. Co-firing modifications will be designed to allow the use of a feedstock supply ranging from 4,000 acres up to the 40,000 proposed for 5% biomass fuel mixture. The major difference will be the cost of additional handling facilities. This approach will allow us to increase co-firing capacity in relation to funds available without large up front engineering costs. Additional design costs may be incurred in Phase II costs if the capacity is significantly expanded.

Co-fire testing will be completed at the direction of R.W. Beck in consultation with IES representatives. Outside contractors will be used as noted. R. W. Beck will also be responsible for design package development. Tasks leading to the final product are as follows:

- 2.1 IES Utilities and R.W. Beck will witness two 4 hour tests and one 100 hour test scheduled for early November, 1996) at MG&E's Blount Street Station located in Madison, Wisconsin. Sized switchgrass will be co-fired with pulverized coal at a ratio of up to 20% switchgrass.
- 2.2 IES Utilities and R.W. Beck will travel to Denmark to meet with representatives of ELSAMPROJEKT A/S, an engineering firm formed by a group of electric utilities in Denmark, to collect design, performance, and actual commercial operating data on their experience in co-firing up to 20% wheat straw in utility-size, pulverized coal-fired boilers.
- 2.3 IES Utilities and R.W. Beck will document and evaluate the data collected in Tasks 1 and 2 with regard to:
 - impact of switchgrass sizing on boiler and ESP performance
 - impact of switchgrass moisture content on boiler performance
 - impact of co-firing on boiler slagging and the marketability of the ash
 - experience with various switchgrass handling systems
 - experience with various burner designs
 - maximum allowable switchgrass/coal ratio
 - lesson learned
- 2.4 IES Utilities, R.W. Beck, and ABB/CE will prepare the following input to ABB/CE's laboratory and bench scale tests:
 - switchgrass and coal supply for testing
 - switchgrass and coal analyses
 - expected range of coal and switchgrass characteristics
 - OGS boiler characteristics

-alternative burner design experience

2.5 ABB/CE will conduct laboratory and bench scale tests to determine the following:

- recommended burner design
- recommended allowable range for switchgrass moisture content
- recommended switchgrass sizing to maximize performance and an allowable sizing range

2.6 Design co-firing and handling facilities at OGS. Based upon co-firing tests, design activities will address needed boiler modifications at the IES facility. This task will be performed by R.W. Beck in conjunction with other participants as needed.

a. Participate in total of five one-day meetings with Chariton Valley RC&D, IES, Farm Bureau, John Deere, and agricultural materials handling equipment suppliers.

b. Meet with boiler manufacturer to determine burner design changes and modifications required for burning switchgrass.

c. Evaluate the material handling options.

d. Perform a qualitative evaluation of materials handling options and select two.

e. Prepare a pre-conceptual design and cost estimate for two material handling option.

2.7 Prepare site plan development. R.W. Beck will develop site plans according to projected modifications required to co-fire switchgrass at the OGS facility:

a. Visit the OGS plant site.

b. Determine the required site preparation work (including roadways).

c. Prepare outline specifications (1-3 pages) for major equipment to include the following:

*Switchgrass handling and storage equipment.

*Switchgrass preparation equipment required to remove switchgrass from storage and deliver to burner front ready for combustion.

d. Prepare the following engineering diagrams (11" x 14"):

*On-site plan diagram indicating the location of all equipment and utilities in the switchgrass handling and storage yard from receiving to inlet of boiler.

*One switchgrass handling system flow diagram identifying process equipment and material flow at the input and output of each process.

e. Prepare a planning level capital cost estimate and construction schedule for all on-site switchgrass-handling equipment and required boiler modifications.

2.8 Assess the commercial potential and transferability of co-firing technology. R.W. Beck is participating in the Chariton Valley Biomass Project on a cost-sharing basis to gain the experience to provide similar assistance to future projects throughout the US, particularly in the Midwest, south central, and southeastern US. Our long-term strategy is to become proficient in assisting utilities and independent power producers (IPP's):

- analyze biomass-firing options at their coal-fired plants
- design and construct the power plant modifications needed to fire the biomass
- procure the biomass fuel through biomass supply contracts with local producers

To promote similar projects throughout the US that will benefit from the lessons learned from the Chariton Valley Biomass Project. Thus, we propose the following subtasks to accomplish both of our objectives.

2.8.1 Comparative analysis of switchgrass utilization options at existing fossil-fired steam power plants.

R.W. Beck will develop conceptual designs and cost estimates for the two leading switchgrass-firing options at existing utility-size, fossil power-plants, namely, the "direct-fired option" and the "gasification option." We do not anticipate this analysis producing a "winner" or "loser", but rather the identification of market niches for each option. For example, we might find that the gasification option could work better in converting oil and gas boilers in order to avoid the potential capacity derating of the direct-fired option, while the direct-option might work better on coal plants in order to avoid the additional capital cost of the gasification system. R.W. Beck will rely on gasifier equipment suppliers to provide cost and performance estimates for the gasification option.

2.8.2 Identify potential switchgrass conversion candidates.

With the help of the US DOE and our own in-house data base, R.W. Beck will identify those utilities and IPP's most likely to convert existing fossil plants to switchgrass.

2.8.3 Telephone survey.

R.W. Beck will conduct a telephone survey of those potential switchgrass conversion candidates identified in Subtask 2 to assess interest level and identify a potential switchgrass conversion project.

2.8.4 Meet with one utility and one IPP.

R.W. Beck, and the US DOE and others as deemed appropriate, will meet with the utility and the IPP that have the most to gain and have demonstrated the most interest in conversion to switchgrass to assess barriers and constraints as well as market drivers. Through discussions over the phone, develop a hypothetical switchgrass co-firing project for the utility and one for the IPP located at one of their coal-fired power plants.

Prepare a formal slide presentation of each hypothetical project estimating land requirements for switchgrass harvest, power plant conversion requirements, switchgrass procurement strategy, project structuring and financing options, project implementation schedule, and project economics.

Present the hypothetical projects to the electric utility and the IPP and assess interest level, barriers, constraints, etc.

3. Gasification Research and Development Program

In addition to the original gasification research proposed with Iowa State Mechanical Engineering and the Iowa Energy Center, solicitation was issued, Chariton Valley RC&D has been presented with the opportunity to participate in the establishment of 6 MWs of biomass generation capacity. If switchgrass proves compatible with the needs of the facility, we could move biomass to commercialization faster and more economically than our original proposal. It would ideally serve as an intermediate step to reaching the co-firing option. A smaller gasifier project would allow a more orderly scale up of biomass supply and a facility for testing feedstock handling from 4,000 acres before moving to the 40,000 level. The total project cost is estimated at \$3.25

million. Part of Phase I resources will be used to assess the potential of this unit as the gasifier for HEC testing detailed in our original response. Fuel cell research will also be addressed regarding this facility.

The gasification facility must be producing hot gas by the end of 1997 to qualify for Section 29 tax credits. The unit itself would initially produce around 6 MW of biomass generated power. The fuel will still be co-fired, but with 60% to 70% wood or paper residues to avoid slagging and other handling problems. Phase I funds would also be used to address the design of a handling system for the gasifier. The handling system would be designed to also be compatible with the co-firing project. Phase II cost share for the set up of this unit as a commercial facility and a fore runner to the larger project proposed with IES.

- 3.1 Perform gasification tests on switchgrass using process development unit located at the Iowa Energy Center.
- 3.2 Conduct a system study to evaluate a biomass gasification/fuel cell power generation system.
- 3.3 Develop a process flow diagram for a biomass gasification/fuel cell power plant.
- 3.4 Study options for a comprehensive system integration between the Direct Fuel Cell (DFC) and the gasification system proposed in order to utilize waste heat from DFC, and maximize overall integrated plant efficiency. Establish an overall process flow diagram of all major process requirements including gas clean-up.
- 3.5 Select a power plant size based on the economics of feedstock availability, gasifier design and economy of scale, fuel cell power plant requirements, and market considerations. Using recent studies of biomass economics, the proposed gasifier design will be evaluated to establish sizing criteria. 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.
- 3.6 Evaluate potential trace contaminants in the fuel stream to quantify expected compositions. Based on feedstock composition, and available experimental data, determine expected levels of trace contaminants that may be harmful to fuel cell operation and life, and may represent environmental pollutants.
- 3.7 Based on the process flow diagram established in 3.3, develop material and energy balances for a biomass gasification fuel cell power plant system at the selected plant size using biomass feedstocks, including switchgrass and waste wood. Estimate preliminary fuel cell power plant capital cost based on derived data, and estimate plant fuel to electric efficiency.
- 3.8 Prepare a final report documenting the results of the above tasks. The final report will include conclusions and recommendations leading to a power plant validation. Support Chariton Valley RC&D in progress reporting and delivery of the final reports to DOE.

Completion by late 1997.

4. **Feasibility of Switchgrass Gasification Using A Relocated Gasifier**

EPI will assess the potential for the relocation and use of a 6 MW gasifier to use a 30% switchgrass mixture. Biofuels Incorporated will develop the business plan and financial package in cooperation with Chariton Valley RC&D. R.W. Beck is designing a compatible fuel handling system as part of work detailed under the co-firing option.

- A. Assessment of steps required to dismantle and relocate gasifier to Iowa location.
- B. Inspection assessment of current equipment condition to include a cost estimate of replacement or refurbishments required to place the facility in service at the new location.
- C. Site plan for erection of the facility at new location.

D. Process flow/energy and mass balance diagrams of the gasifier.

This task will be completed within six months of award.

5. **Switchgrass Fuel Supply Plan Development and Demonstration for Commercial Facility Startup**

The feedstock activities outlined herein will result in an initial supply of 4,000 acres of biomass. Field level implementation will be carried out by Iowa State University Extension, the Natural Resources Conservation Service and the Farm Service Agency and Chariton Valley RC&D, with the assistance of John Deere Works of Ottumwa, the Farm Bureau and local farmers. Switchgrass has considerable potential as a biofuel, but improvements in the management and genetics of the crop are needed to make it profitable for farmers and energy producers. A team of forage agronomists with expertise in breeding, management, utilization and quality have identified several areas to begin experiments to improve switchgrass and its culture. Research and development on switchgrass management and harvest activities include:

5.1 **Improve the local producers ability to establish, manage and deliver switchgrass**

Chariton Valley RC&D has been concentrating on the demonstration of energy crop production for the past four years. This component will continue through Phase 1. This will consist of management research designed to improve establishment techniques and to cost effectively increase yields. Work will continue on maximizing fertilizer inputs relative to switchgrass varieties and to soil characteristics. Switchgrass will be established in various types of situations that will be encountered in a feedstock scale up process. Specifically, the use of CRP acres will require the conversion of existing cool season stands to switchgrass. Switchgrass will also be established following different types of annual crops. Information relative to soils and inputs will be collected and entered into a GIS-based data layer for further analysis. Yield data will be extrapolated to the four county area using GIS to predict supply curve information.

5.2 **Assessing the genetic variability for biofuel traits**

Switchgrass, once established, can produce large yields of biomass. However, little work has been conducted to identify variability for important biofuel traits, and no currently available switchgrass cultivars have been specifically selected for biofuel traits. Because switchgrass cultivars are comprised of many diverse genotypes, selection for improved biofuel traits is highly likely to result in improved germplasm. A sensible beginning point in developing improved cultivars is to assess the variability in current cultivars for various traits important for production and burning quality. A replicated trial will be planted including 14 switchgrass cultivars and germplasm populations. This test will enable us to examine a range of populations for variation in important traits.

The establishment abilities of the different cultivars will be measured by stand counts at three dates during the establishment year. Total biomass yield will be measured in the fall on two replicates of the study and in the following spring on the other two replicates. This will enable us to get an idea of the feasibility of storing the biomass "on the stump" rather than having to harvest everything in the fall. At each harvest time, samples will be taken for further analysis. Leaf:stem ratios will be calculated based on hand separated material. It is currently unclear how this will effect the burning ability of switchgrass.

Burning characteristics are vitally important but have not been studied in any germplasm. With this test, we have the capacity to identify cultivars with superior burning characteristics, and ones that maintain those traits over winter. Several traits will be analyzed. The amount of ash produced by burning will be determined. Further, the ash content will be analyzed for silicates and other constituents, such as nitrogen, and the pH will be determined. Leaves and stems can be burned together and independently to determine if one burns better than the other. In all these analyses, the 14 different cultivars providing a measure of the genetic diversity present in the currently available germplasm.

This experiment is a necessary first step in identifying and selecting superior plants for the development of improved cultivars. New cultivars take about 12 years to develop and release, so initiating a germplasm evaluation in the early stages of the bioreactor research will allow new cultivars to be produced as the reactor becomes fully operational.

Assess and demonstrate biomass harvest methods to include storage and transport modeling. Initial work sponsored by DNR and carried out with ISU Extension field staff have begun the process of establishing baseline data. A copy of this report is available. This work would be continued as part of the overall feedstock research component. John Deere has indicated continued support through the RC&D for harvesting. These costs have been included in RC&D budget.

5.3 Determining the effect of timing of harvest on burning qualities

Little research has been conducted on the burning of switchgrass. Genotype variability will be assessed under objective 2 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 experiment 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. Burning traits, including those listed above, will be conducted on this material. The change over time will be tracked during the six sampling dates.

5.4 Evaluating harvest and handling equipment

The equipment used to harvest switchgrass will be constrained to some extent by the needs of the bioreactor and by the needs of the farmer. Currently, many farmers use large round balers to harvest hay and straw. The bales produced are not easily handled or hauled. Conversely, large (4' x 4' x 8') or intermediate (2' x 3' x 8') square bales are easier to stack and transport but the balers are not widely used by farmers, particularly in southern Iowa. This study is intended to study the feasibility of using large round and square bales on the farm and at the combustion site.

This experiment consists of three parts:

- (1) to evaluate the potential of large round and large square balers to produce a package usable by the biomass plant,
- (2) to evaluate different mechanized handling equipment for its usefulness with each bale type, and
- (3) to assess the economic viability of custom harvesting and handling of large bales. Equipment is available to make differently sized biomass packages. Currently available switchgrass stands will be harvested in fall 1996 by the different methods to determine which one produces the most profitable and easily handled biomass package.

5.5 Economic analysis of energy crop production, impacts upon the local economy and market potential

Regardless of scale, there is very little crop budget information available to farmers and producers that includes cost of production including establishment, management, harvest, handling and transportation of switchgrass as a biomass crop. Initial work by Chariton Valley RC&D and supporting partners in the NREL-funded feasibility study quantify to some degree several of these components. The transfer of energy crop technology requires that we assemble and massage crop budgets for biomass production and document and disseminate this information.

This task will result in detailed cost budgets to include for a range of farm operation scales that would likely establish 50 and 200 acres of energy crops. Information will be collected during the establishment of project switchgrass acres. Data collection will include several components. Each field operation, the time it takes to complete each field operation, and the equipment and fuel used must be properly documented. Once collected this data can be analyzed to document the cost of production for different size farm

enterprises, and an average per-acre farm production budget for switchgrass to energy.

An agricultural economist will design the data collection formats and an ISU Extension field agronomist will work with farmers to collect the data. The economist can then develop base data similar to that available for all other types of crop production. This is expected to include:

- *Pre-plant preparation, planting, cultivating operations and any additional passes through the field.
- *Seed, herbicide and pesticide cost.
- *Scouting labor, fuel and machinery costs to include custom operations.
- *Fixed and variable cash costs, land costs including insurance and taxes.
- *Production management scenarios be proposed corresponding to the till and no-till options available to farmers.
- *Various machinery complements be assembled with regard to capital cost and custom application for growing, harvesting, handling and transporting switchgrass.

Per-acre average returns to land, labor, capital and management.

Because there are expected shifts in, and economic effects on agricultural communities as a result of development of new agricultural crops and agricultural markets, it is important to develop the basic underpinnings for input/output models. These input/output models should include several business and technology sectors. They will assist county and community developers and leaders in determining the direct and indirect economic effects as a result of establishing large areas of switchgrass for energy. For example, for every 10,000 acres of corn planted in a locality, economists know that \$Y machinery and implements are sold, that P persons are employed as a result, that per capita on-farm rises by some factor, and that per capita off-farm income rises by some factor. These types of analyses are not only important for the agricultural and marketing side of the story, but from the potential energy market. The analyses may be conducted on a county level, or even less than a county level. A good I/O may include surrounding counties to capture other spillover effects. Analyses could be based on currently existing I/O models.

Another important part of the research that should be accomplished is a comprehensive marketing study and plan. There are and have been several marketing alternatives considered as a result of agriculturally produced, renewably derived energy resources. Two of them currently being considered are the farm producer/marketing cooperative, and fixed-price contracts between suppliers and demanders with annual payments to farmers. This study should dovetail directly into the current agricultural markets based on the four-county region in the Chariton Valley area. Inherent in this marketing study will be a survey of farmers that will allow researchers, demanders, and suppliers of energy sources to determine potential market drivers as agricultural commodities and ensuing markets are developed. This will provide insight as to why farmers make decisions they make when considering their whole-farm budgets and the mix of crops and enterprises to support. This type of survey can also tell how individual farmers make their land-use decisions, which have direct implications for developing markets and hence, the entire industry.

This work will be completed through a cooperative agreement with NRCS or Iowa State University to contract for these services.

Estimated time to complete is up to 2 years.

5.6 Obtain commitments on 4,000 acres and enter agreements to obtain management harvest information and ultimately biomass to supply co-firing and gasification activities.

Chariton Valley RC&D has been granted access to use ⁴⁰⁰⁰400 acres of Conservation Reserve Lands for research

and for use as a source of harvested biomass. Approximately 1,500 acres of switchgrass have been identified and scheduled for establishment in 1996 and 1997. These include a number of acres entered into the last CRP sign up. Landowners have signed statements of intent.

Chariton Valley currently has access to approximately 500 acres of switchgrass through management agreements with DNR. We have identified approximately 200-300 acres in current switchgrass stands under CRP contracts where landowners would participate. To increase acres available to the stated goal, we will continue to target CRP participants. Given the time required to develop an energy crop market, landowners must have some annual compensation while the biomass crop is established and demand created.

- Capture new CRP sign up acres for biomass planting and assist with establishment.
- Identify existing cool season grass CAP acres for conversion demonstrations.
- Develop specific agreement for producer commitments.
- Determine methods of compensation to landowners for required data gathering.
- Gather data on all tracts identified specific to methods of establishment, success, and yield data.

Research tasks will be carried out in conjunction with general scale-up activities through personnel provided by ISU Cooperative Extension Service and Iowa State University Agronomy Department. The 4,000 acre scale-up acres will provide the basis for the economic and agronomic data to be gathered. In addition to the field cost associated with data collection and project management, funds will be required to establish energy crops. It is estimated that cost share for approximately half of the 4,000 acres can be obtained through other sources. We are including approximately \$250,000 in the project budget for establishment of the remaining 2,000 acres.

Completed through three growing seasons 1996, 1997 and possibly 1998.

6. **Project and Performance/Guarantees and Warrantees**

These items will be included as part of the design package in the case of the co-firing portion of the project.

7. **Construction and Environmental Permits**

These permits will be secured as appropriate by IES and/or Biofuels Inc. with the assistance of Iowa DNR

- A. Identify Iowa and EPA requirements.
- B. Determine current status of OGS and/or gasifier facility.
- C. Review emissions data projected for project.
- D. Obtain necessary Iowa permits through cooperation with DNR.

8. **Environmental Analysis Planning**

The NRCS has well documented the differing erosion rates of marginal land under perennial cover versus more intensive annual row crops which sometimes exceeding 20-30 tons per acre per year. Conversely many of the soils have a lower than average tolerance for erosion of less than three tons per acre per year. Soil resources in the area tend to be less productive based upon the widely accepted system of Com Suitability Ratings (CSRs). In the four-county area soils productivity averages a score of 50 on a scale of 5-95 used state wide. Therefore, unchecked use can result in erosion rates greater than 10 times acceptable

while still only producing mediocre yields.

The Conservation Reserve Program was targeted to address this problem. Within the total Chariton Valley RC&D area of 1.4 million acres, 140,000 acres is in the Conservation Reserve Program (>10%). The question becomes how to maintain the advantages of the CAP when it ends or how to reduce the costs of the CAP and extend the program through energy crop production on CAP acres. The use of agricultural products as a source of renewable energy is attractive from a long term resource management perspective. The associated benefits to water quality and sustainable soil capabilities need to be further documented to support the potential of energy crops in the local agricultural economy.

These environmental and sustainability questions need to be addressed for herbaceous energy crops, particularly as projects move from research scale plots to larger plantings. The large establishment area planned in this project offers an opportunity to isolate studies from different adjacent land uses to better determine specific environmental effects of biomass plantings on water quality, soil stability, soil quality, and wildlife habitat. Because of the absence of specific information on environmental research associated with energy crop plantings in the Chariton Valley, specific research is proposed for inclusion in this commercialization effort. These studies can provide the data necessary to determine the environmental benefits that can accrue from location of switchgrass plantings in the agricultural landscape and can provide comparable data for comparison with studies of biomass crop production in different regions of the country. The Division of Soil Conservation in Iowa, in cooperation with the local soil and water conservation districts will provide support data for expected soil, water, and air quality associated with biomass power and energy crops. Chariton Valley RC&D will provide technical support through GIS capabilities. This task will:

- A. Estimate potential and actual soil losses as land is identified.
- B. Employ GIS to perform watershed analysis and provide monitoring in the Rathbun Watershed to target CRP supply for maximum benefits.
- C. Evaluate soil and water benefits of biomass throughout Iowa.
- D. Evaluate CO₂ sequestration potential of biomass and other sustainable practice.

Chariton Valley RC&D will acquire personnel and equipment to complete the first two of the above tasks, to identify the location of existing CRP lands in the target watershed and the RC&D area. Soil and water impacts of current area land use will be identified and compared to the effects of biomass crops on erodible and other fragile lands. This information will be compiled to document the potential impacts on water quality associated with energy crops. The social or external costs will be identified to provide a more complete view of the economic benefits of biomass to follow or complement the current CRP.

8.1 GIS Component

Field sites chosen for planting will be mapped in a fashion to capture soil types and clones selected for planting. This will include a geo-referenced digital data layer to be overlaid upon soils information for current and future spatial analysis.

This will allow to overlay data on clonal test material block plantings, as well as production acres, maps should be drawn to scale so researchers have the ability to overlay soil maps on clone maps after planting/harvest. Over a 10 year period of time across 4,000 acres, agronomists and others should be able to determine overall yield as a result of site/clone matching.

8.2 Soil Quality

Soil descriptions of the major soil types proposed for location of switchgrass plantings in the Chariton Valley area prior to establishment of the plantings will provide the necessary background data to assess physical and chemical changes in soils resulting from conversion of agricultural lands to switchgrass production. This

8.5 Carbon Sequestration

The assembly of land use data and the location of CRP and biomass planting will provide the basis for predicting the CO₂ impacts of biomass from the feedstock perspective. Given the availability of data on the amount of carbon removed from the atmosphere during different types of crop production, GIS modeling can be used to gauge the impact of this project. Added to this will be an assessment of CO₂ benefits from the displacement of coal and other fossil fuels in the generation of electricity.

APPENDIX THREE

INTERNET VIRTUAL OFFICE

<http://webbook@ameslab.gov>

Chariton Valley Biomass Power Project Virtual Office

You Are Visitor Number 5 Today

Welcome to the Chariton Valley Biomass Power Project Virtual Office! The purpose of this page is to improve project management and coordination of the cooperative research and development pact between Chariton Valley RC&D and its public and private partners. Upon completion, members of the working group will be able to access shared materials via any internet-ready computer.

Materials will be made available as construction of the site continues and will tentatively include the workplan, an organizational chart, a scheduling utility, an archive of quarterly and miscellaneous reports, a mail utility and archive of electronic mail, an address and telephone directory of individual group members, and a map of converted switchgrass acres in Iowa. These materials may be accessed from this page by clicking on any one of the following items, or by clicking on its representative object in the virtual office.

- workplan [*books atop file cabinet*]- a description of each primary task as set forth in the "Statement of Work."
- organizational chart [*chart on right wall*] - an organizational chart showing the informal reporting hierarchy for project activities.
- schedule [*calendar on far wall*] - a scheduling utility for task management, milestone tracking, and electronic scheduling.
- directory [*telephone on desk*] - an address and telephone directory of individual working group members, including e-mail links.
- map [*map on left wall*] - a map of Iowa highlighting converted switchgrass acres.
- reports [*open file drawer*] - an archive of quarterly progress and other miscellaneous reports.
- e-mail archive [*PC monitor*] - an archive of electronic mail messages distributed to the working group.
- "for review" depository [*in-box on desk*] - a mail utility for electronic routing and group review of draft reports, charts, etc.

For comments or questions contact: Warren Straszheim.

This page last updated on December 18, 1996.

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Chariton Valley Biomass Power Project

Statement of Work

1.0 NEPA Process

2.0 Design Package Development for Co-firing Option

3.0 Gasification Research and Development Program

4.0 Feasibility of Switchgrass Gasification Using a Relocated Gasifier

5.0 Switchgrass Fuel Supply Plan Development and Demonstration for Commercial Facility Startup

6.0 Project and Performance/Guarantee and Warranties

7.0 Construction and Environmental Permits

8.0 Environmental Analysis Planning

Chariton Valley RC&D, Inc.

STATEMENT OF WORK

3. Gasification Research and Development Program

In addition to the original gasification research proposed with Iowa State Mechanical Engineering and the Iowa Energy Center, solicitation was issued. Chariton Valley RC&D has been presented with the opportunity to participate in the establishment of 6 MWs of biomass generation capacity. If switchgrass proves compatible with the needs of the facility, we could move biomass to commercialization faster and more economically than our original proposal. It would ideally serve as an intermediate step to reaching the co-firing option. A smaller gasifier project would allow a more orderly scale up of biomass supply and a facility for testing feedstock handling from 4,000 acres before moving to the 40,000 level. The total project cost is estimated at \$3.25 million. Part of Phase I resources will be used to assess the potential of this unit as the gasifier for HEC testing detailed in our original response. Fuel cell research will also be addressed regarding this facility.

The gasification facility must be producing hot gas by the end of FY 1997 to qualify for Section 29 tax credits. The unit itself would initially produce around 6 MW of biomass generated power. The fuel will still be co-fired, but with 60% to 70% wood or paper residues to avoid slagging and other handling problems. Phase I funds would also be used to address the design of a handling system for the gasifier. The handling system would be designed to also be compatible with the co-firing project. Phase II cost share for the set up of this unit as a commercial facility and a fore runner to the larger project proposed with IES.

3.1 Perform Gasification Tests on Switchgrass

Perform gasification tests on switchgrass using process development unit located at the Iowa Energy Center.

3.2 Conduct Gasification/Fuel Cell Power System Study

Conduct a system study to evaluate a biomass gasification/fuel cell power generation system.

3.3 Develop Process Flow Diagram

Develop a process flow diagram for a biomass gasification/fuel cell power plant.

3.4 Study Options for Comprehensive System Integration

Study options for a comprehensive system integration between the Direct Fuel Cell (DFC) and the gasification system proposed in order to utilize waste heat from DFC, and maximize overall integrated plant efficiency. Establish an overall process flow diagram of all major process requirements including gas clean-up.

3.5 Select Power Plant Size and Design

Select a power plant size based on the economics of feedstock availability, gasifier design and economy of scale, fuel cell power plant requirements, and market considerations. Using recent studies of biomass economics, the proposed gasifier design will be evaluated to establish sizing criteria. 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.

3.6 Evaluate Trace Contaminants to Quantify Compositions

Evaluate potential trace contaminants in the fuel stream to quantify expected compositions. Based

on feedstock composition, and available experimental data, determine expected levels of trace contaminants that may be harmful to fuel cell operation and life, and may represent environmental pollutants.

3.7 Develop Material and Energy Balances for Biomass Fuel Cell Power Plant System

Based on the process flow diagram established in 3.3, develop material and energy balances for a biomass gasification fuel cell power plant system at the selected plant size using biomass feedstocks, including switchgrass and waste wood. Estimate preliminary fuel cell power plant capital cost based on derived data, and estimate plant fuel to electric efficiency.

3.8 Prepare Final Report to Document Results of Tasks Performed

Prepare a final report documenting the results of the above tasks. The final report will include conclusions and recommendations leading to a power plant validation. Support Chariton Valley RC&D in progress reporting and delivery of the final reports to DOE.

Completion by late 1997.

Chariton Valley Biomass Power Project Organizational Chart

Schedule+ - [CFCE Web Book]

File Edit Appointments Tasks Options Window Help

Thu, Dec 19, 1996

December 1996

S	M	T	W	T	F	S
24	25	26	27	28	29	30
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	2	3	4

Notes:

8:00AM

9:00

10:00

11:00

12:00PM Stakeholders Meeting
Center for Coal and the Environment
Ames IA

1:00

2:00

3:00

4:00

5:00

6:00

7:00

6:01PM Wednesday, December 18, 1996 8:00AM - 8:30AM

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(Remember many viewers may use the "find" function, e.g., Ctrl+F in Netscape)

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Acreage Converted to Switchgrass Production (by county)