OVERVIEW OF THE CHARITON VALLEY SWITCHGRASS PROJECT: A PART OF THE BIOMASS POWER FOR RURAL DEVELOPMENT INITIATIVE

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ABSTRACT

Investigation of renewable energy in Iowa is centering on the use of agricultural crops to generate electricity. Switchgrass, a native grass of Iowa, is one of the most promising biomass producers. Chariton Valley RC&D Inc., a USDA affiliated rural development organization based in southern Iowa and Alliant Power, a major Iowa energy company, are leading a statewide coalition of public and private interests to develop a sustainable biomass industry. Chariton Valley RC&D is working with local producers and the agricultural professionals to develop a biomass supply infrastructure. Alliant Power is working to develop the technology to convert agricultural crops to energy to serve as the basis for sustainable commercial energy production. Iowa State University and others are assessing the long-term potential of gasification for converting switchgrass to energy.

Plans call for modifications to a 750 MW Alliant Power coal plant that will allow switchgrass to be co-fired with coal. A 5% co-fire rate would produce 35 MW of electrical power production and require 50,000 acres of dedicated biomass supply in southern Iowa. Growing biomass crops on erosive lands, then using them as a substitute fuel in coal-fired boilers can potentially reduce air pollution, greenhouse gas emissions, soil erosion and water pollution.

Keywords: switchgrass, Chariton Valley RC&D, rural development

PROJECT BACKGROUND

Concerns over fossil fuel use, dependence on foreign energy, and associated environmental impacts are all important factors in an emerging interest in the use of biomass. United States energy policy recognizes the potential and seeks to secure "a more efficient, less vulnerable, and environmentally sustainable energy future" (DOE, 1991). In 1992, the U.S Department of Energy (DOE) indicated that the development of a sustainable biomass energy program in the U. S. was desirable for a number of reasons. Dedicated energy crops were identified as a major long-term source of renewable fuel to establish domestic energy independence, address global warming, relieve over-

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production in the agricultural sector, reduce water pollution and increase rural incomes (DOE, 1992).

The Midwest, and especially Iowa, has been recognized as having a high potential for energy crop production (Brower, 1993). Switchgrass, a herbaceous species native to Iowa, has been cited as having high potential as an energy crop (Woolsey, 1992; McLaughlin, etal. 1995). Switchgrass can reduce soil erosion to almost zero, requires relatively low inputs, grows well on marginal soils, and adds significant amounts of carbon to the soil as a sequestering method for atmospheric CO2 (Downing etal 1993).

Formal efforts to encourage the use of biomass within the DOE and the U.S. Department of Agriculture (USDA) merged with the issuance of the Biomass Power for Rural Development (BPRD) request for proposal in December of 1995 (DOE Solicitation DE-PS36-95GO10052). This initiative, a five-year collaborative effort between USDA and DOE, "seeks to demonstrate and deploy integrated biomass power systems that are economically and environmentally viable and sustainable".

Stated expectations of successful projects include:

- Demonstration of integrated biomass supply systems with power conversion technologies;
- Introduction of alternative energy crops as a means to offset federal agricultural subsidy payments;
- Economic revitalization of rural America and job creation;
- Reduction of greenhouse gas emissions;
- Improvements in biodiversity and ecological health; and
- Creation of a U.S. industry with significant export potential.

Solicitation responses resulted in the funding of three projects nationally; each project included a utility partner and a coalition of local agricultural interests to address the commercial potential of both woody and herbaceous energy crops (DOE Press release). One of these projects has emerged as the most promising of the four in terms of the public-private partnership committed to the effort, viability of the technical approach, and overall potential for success (Conway, 1997). This project, sponsored by Chariton Valley Resource Conservation and Development (RC&D) Inc., a rural development oriented non-profit corporation in partnership with Alliant Power, a major Iowa utility, seeks to establish a viable energy crop industry in southern Iowa. The Chariton Valley Project is based upon the use of switchgrass as a substitute for coal. The effort has generated significant support from state and local organizations developed through a locally directed public-private coalition.

Chariton Valley RC&D, Inc. receives direct technical assistance from USDA through the Resource Conservation and Development (RC&D) Program, authorized by Section 102 of the Food and Agriculture Act of 1962 (P.L. 87-703). The RC&D differs from other government agencies in that local citizens through the RC&D Council carry out the program. The council includes representatives of the local governments in the defined

RC&D area. The stated purpose of the RC&D Program "is to accelerate the conservation, development, and utilization of natural resources, to improve the general level of economic activity, and to enhance the environment and standard of living in authorized RC&D areas."

Much of the philosophy of RC&D and its actions in support of biomass is based upon the grassroots objective of creating markets for locally sustainable resources to increase rural incomes and job opportunities. While the primary local objective of the Chariton Valley Project is to increase rural incomes through sustainable agricultural endeavors, the project success is reliant upon valuing the numerous environmental benefits that can potentially be had through the project. Current economic and natural resource based problems found in the RC&D area are attributable to U. S. agriculture policy of the 1970's and early 1980's. Commodity programs encouraged unrestricted conversion of land from grassland to row crops. This accelerated soil erosion and associated damages. The region relies heavily on a rural water distribution system fed by Lake Rathbun. The lake watershed is directly impacted by the land uses of area soils. The Conservation Reserve Program (CRP), established in 1986, has paid landowners to return much of the land to grass. CRP program benefits have reduced erosion and stabilized incomes; however, energy crops are seen as possibly a more permanent solution.

Chariton Valley RC&D and other coalition participants propose to make modifications at an Alliant Power coal-fired boiler to allow the use of switchgrass as an alternative fuel source. Alliant Power is participating in the project to determine the feasibility of using a dedicated supply of southern Iowa biomass as a fuel source. At the proposed capacity of 35 MW, the facility would require an estimated 50,000 acres to produce a dedicated supply of switchgrass. This would create a new agricultural market for southern Iowa farmers and a use for land currently in CRP.

SWITCHGRASS TO ELECTRICITY: THE CHARITON VALLEY CONVERSION TECHNOLOGY

Conversion of biomass to electric energy can be accomplished through a variety of technologies. The most likely near-term method is the use of biomass in a conventional steam boiler system to power a generating turbine. The biomass can be used alone or co-fired with coal. Gasification is a more long-term technology still in development stages with regard to biomass use. It is considered to be more efficient than direct combustion, but also requires a new facility at a much higher investment cost (DOE 1992).

The Chariton Valley Project is focused upon the use of an existing coal-fired power plant as the initial conversion facility for the dedicated switchgrass crop. Much of the following description and associated discussion of the project comes from unpublished reports, correspondence and internal project communications about the conversion methods. In addition a feasibility study was completed by Black and Veatch Engineering in 1995 and distributed by RC&D.

The proposed co-firing scenario consists primarily of two components described in detail in the feasibility study prepared by Black & Veatch (1) boiler modifications and (2) switchgrass processing and handling equipment. These two areas represent the largest investments required by the utility to implement a biomass power project. The modifications to the existing coal boiler needed to co-fire switchgrass and the equipment needed to harvest, transport, and prepare the switchgrass for the boiler all can be done with conventional technology (Black and Veatch, 1995).

Alliant Power proposes to modify its Ottumwa Generating Station (OGS). OGS is a 726 MW coal unit located on a 375-acre site adjacent to the Des Moines River, approximately seven miles northeast of Ottumwa, Iowa. The plant, operated by Alliant Power, Inc. and co-owned with Midwest Electric, entered commercial service in May 1981. From 1989 through 1993, OGS used an average of 61% of its total potential capacity and generated an average of 3,642,000 MWh of electrical energy per year. The boiler at OGS is a pulverized-coal, drum type, forced circulation unit which was manufactured by ABB Combustion Engineering, Inc. (ABB-CE). At maximum continuous rating, the unit has a main steam flow of 4,850,000 lb./h at 2,640 psig and 1,005 F at the superheater outlet. The corresponding reheat steam flow is 4,440,000 lb./h at 1,005 F at the reheater outlet. The boiler contains 56 coal burners which are located on seven levels with eight tilting tangential burners arranged in two groups of four burners on each level. The two groups of four burners provide two distinct fireballs within the boiler. The rest of the steam generating equipment consists of seven coal pulverizers, two regenerative air heaters, two primary-air and forced-draft fans, and four induced-draft fans.

The unit was designed to fire low sulfur Wyoming sub-bituminous coal that is delivered to the site by rail in 110-car unit trains. An average of four unit trains per week are received and unloaded in a rotary dump facility. OGS currently has no sulfur dioxide emission controls. Bottom ash from the boiler is sluiced directly to an on-site storage bin. The fly ash is collected by hot electrostatic precipitators and pneumatically conveyed to a large storage silo. The fly ash is then sold for cement replacement and soil stabilization. The fly ash sales are contingent on the ash meeting the standards listed in ASTM C618.

The preliminary design for boiler modifications to allow the use of switchgrass was proposed by ABB-CE, and are currently being reviewed and finalized by Alliant Power in consultation with R. W. Beck Engineering and the National Renewable Energy Laboratory. The modifications to existing facilities required to co-fire switchgrass are relatively minor and Alliant anticipates their completion in 1999. Switchgrass baled with conventional hay balers would be delivered to the facility. The material would be ground to 1" to 1 1/2" sized pieces to allow pneumatic transporting and injecting of the switchgrass into the boiler. The sized switchgrass would enter the steam generator building through nozzles located midpoint to the coal burner elevations. This method is similar to the pulverizing and injection of coal currently used at OGS. Sustaining switchgrass co-firing at the 5 percent level requires the delivery of approximately 25 tons per hour to the boiler during full load operation. At a weight of 1000 lbs. per bale, a total of fifty bales per hour must be sized and delivered to the boiler.

Preliminary assessments by Black & Veatch, subsequent work by R. W. Beck and ABB-CE support the technical viability of co-firing biomass in the Alliant Ottumwa Power Plant. Plans are to burn a minimum of 5% switchgrass or 200,000 tons/yr. Co-firing this amount of biomass with coal will result in 35 MW of renewable-based production capacity while avoiding the large capital risk associated with building a new biomass power plant. Co-firing less than 15% biomass will avoid ash-fouling problems sometimes associated with the use high-alkali content biomass in gasification technology systems. The use of an existing facility will simplify design procedures, minimize the cost of conversion, and provide an existing distribution system for generated electrical energy.

The role the utility plays in this project cannot be overstated. This is especially true in light of the current costs of biomass compared to coal. Costs of delivered switchgrass range from $50 - $60 per ton. Alliant currently pays approximately $15 - $20 per ton for coal. While a seemingly large difference, the issues surrounding renewable energy pricing and power generation are complex. Public concerns and the resulting policies can quickly close the price gap (Cooper, 1998). Utility interest is partially based on its need to address the potential of regulation. Co-firing biomass presents a number of environmental benefits including the reduction of greenhouse gases. These benefits have not been valued yet, but Alliant officials see that possibility in the next few years. Another possibility is a federal or state requirement that utilities generate a certain percentage of electricity from renewables. This scenario would likely be connected to the deregulation of what utilities can charge and where they can sell electricity. These requirements could easily create a niche market where switchgrass is compared to other more expensive renewables, not to coal.

DEVELOPING A DEDICATED FEEDSTOCK SUPPLY

The Natural Resource Conservation Service (NRCS) estimates that more than three-quarters of all the cropland in southern Iowa are subject to excessive soil erosion when used to produce traditional row crops. Many of the soils of southern Iowa are however well suited to the production of perennial forages and grasses. Farm program changes, and the eventual end of the CRP makes adding value and establishing long-term markets for perennial forage crops vital for the area's continued prosperity. Energy crops provide such an opportunity and are attractive from a long-term resource management perspective because of benefits to soil, air and water quality and through improvements in the local economy.

A major impasse in many biomass projects is the need for established energy crops prior to the construction or modification of a biomass power facility. Concerned about availability and reliability, energy producers are hesitant to install biomass-based technologies. Conversely, producers have no incentive to establish a large-scale biomass plantation to demonstrate the ability of agriculture to produce biomass, because there is no current market.

Use of CRP acres for biomass provides southern Iowa producers the ideal way to demonstrate the ability to produce energy crops. CRP use reduces the risk for producers by providing an income during establishment of the crop and market development. Having a biomass crop available and waiting will in turn encourage energy producers to proceed with modification and improvements to use biomass.

The Chariton Valley RC&D area has received authorization from the USDA to use existing CRP land for a 4,000-acre demonstration project supporting the development of energy crops as a post-CRP alternative (Memo from USDA, Letter from the Farm Services Agency). These acres are currently being used for project research and development activities to improve switchgrass production methods and a source of biomass for combustion testing. Project participants from Iowa State University and the RC&D are working with local farmers to improve agronomic management procedures, harvest and transportation efficiency and to conduct technology transfer into the agricultural community during proposed feedstock scale-up.

A major part of the Biomass Power for Rural Development initiative in the Chariton Valley area is feedstock research and demonstration. A number of activities are underway that will provide soil-specific production costs and yield data, as well as, better-defined methods and costs for establishment, harvest and transport of switchgrass for biomass.

PROJECT ACTIVITIES 1998 – 1999

The following activities are excerpted from the project statement of work currently proposed for the next two years.

<u>Co-Fire Testing at Alliant Power's Ottumwa Generating Station</u>

Test objectives include: (1) assess the impacts of co-firing switchgrass on net plant output and plant availability; (2) evaluate capabilities of windbox modifications and conveyance system to deliver switchgrass at required rates; (3) analyze impact of co-firing switchgrass on boiler slagging and fouling, ash, and stack emissions. The test will be conducted at Alliant's Ottumwa Generating Station (OGS). The test will occur during the fall of 1999 or spring of 2000. The test is currently planned to include approximately 60 hours of total burn time.

Approximately 1,500 tons of switchgrass required for the co-fire test will be harvested, transported to, and stored on-site at OGS. Temporary storage facilities will be constructed at OGS. Local producers will be primarily responsible for developing the switchgrass procurement plan and for coordinating implementation activities.

Switchgrass Fuel Supply Development and Demonstration

Feedstock activities will result in an initial supply of 4,000 acres of biomass. Field level implementation will be carried out by Iowa State University (ISU), the Natural Resources Conservation Service (NRCS), Farm Service Agency (FSA) 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 working with the project has identified specific areas of research to improve the production of switchgrass for biomass. These areas include:

Fuel Quality Analysis - Stands of switchgrass at different locations and under different management will continue to be evaluated for burning characteristics i.e., proximate and ultimate analyses, at critical points during the project's development, e.g., 1998/1999 harvest.

Evaluating Harvest and Handling Equipment - Assess and demonstrate biomass harvest methods including storage and transport options. Initial work sponsored by DNR and carried out with ISU field staff has established baseline data. A copy of this report is available. This work would be continued as part of the overall feedstock research component.

Biomass Procurement System Design - One of the primary challenges of the project is to maintain feedstock costs as low as possible. In order to minimize total feedstock harvest, transport, handling and processing costs one needs to look at several different front end processing technologies and their interactions, as well as their impact on the equipment requirements and operating costs at the processing facility. The purpose of this task is to identify and evaluate alternative biomass procurement systems, i.e., harvest, transport, material preparation, in order to determine that which is best suited to our specific region and which delivers feedstock at the most cost competitive rates

Field Coordination and Stand Maintenance

The project will continue to provide field coordination support to researchers and cooperating producers. Planned tasks include the fertilization of approximately 1,150 acres of post-harvest land in switchgrass and 2,750 acres of newly established switchgrass in the year following seeding as well as second seeding on approximately 700 acres.

Biomass Cropping Systems

Many landowners in southern Iowa are not knowledgeable about the management of switchgrass, particularly as an energy crop. At the same time, intensive management of switchgrass to achieve the highest possible yields and per acre return is of primary importance to the development of the biomass energy industry in southern Iowa. Farm

level technical assistance and demonstration activities will provide landowners the skills to manage switchgrass-based biomass cropping systems for optimum economic return and yields. Biomass cropping systems and related techniques that may include: (1) the combined production of early season, high quality switchgrass, legume, and cereal hay followed by late season biomass; (2) the combination of intensively managed livestock grazing followed by late season biomass production; and (3) the establishment and management of switchgrass-based buffer strips for biomass production in areas adjacent to surface water bodies and intermittent drainage. These activities will directly establish and improve the management and productivity of switchgrass biomass in southern Iowa.

Sales Contracts and Biofuel Market Development

The commercialization of switchgrass as a dedicated biomass feedstock in southern Iowa is dependent on the economic viability of the project. Factors that may contribute to favorable economic conditions are tax incentives for renewable fuels, creative contractual arrangements such as tolling, and the marketing of the green energy. There is need to develop formal relationships between the producers and buyers of switchgrass and electricity. In addition to addressing the issue of tax incentives, this activity will produce model legal tools such as agreements and contracts essential to the future marketing of switchgrass.

Environmental Analysis and Planning

Accomplishment of Environmental Analysis and Planning will provide an understanding of the environmental impacts of producing and using switchgrass as a biofuel necessary to encourage support for the developing biomass energy industry. Results will be presented in the form of a report and geographic information system (GIS) products.

Soil resources in the area tend to be less productive and more erosive. Unchecked use can result in erosion rates greater than ten times acceptable while still only producing mediocre yields. The Conservation Reserve Program (CRP) 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 CRP (>10%). The question becomes how to maintain the advantages of the CRP when it ends or how to reduce the costs of the CRP and extend the program through energy crop production on CRP 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 the project moves from research scale 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 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 locating switchgrass plantings in the agricultural landscape and can provide data for comparison with studies of biomass crop production in different regions of the country.

Information and Education

Public support for the project will be enhanced through a greater understanding of the benefits associated with the production and use of biomass to generate energy. The purpose of this task is to provide public information and education needed to sustain the project's momentum through to completion. Activities will include: contracting an information specialist, regular project press releases, a project brochure and display materials, quarterly newsletter, field days and demonstrations and extension publications.

CONCLUSIONS

Commercialization of biomass in the Chariton Valley Biomass Project requires both technical and economic policy considerations. The proposed methods to produce, deliver, and convert switchgrass to energy are based upon existing but varied technologies not heretofore merged in a single complete system. The economic circumstances are based upon current or likely government interventions that will support the equalization of the market value of biomass relative to coal. The success of the project relies upon an incremental process where increasing comfort with the technology and actual demonstration of biomass use supports policy changes. Policy changes support further integration of the technology and provides incentive for greater efficiencies.

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