Final Technical Report

Project Title: Switchgrass Demonstration Project
Award Number: GO14219

Recipient: The University of Tennessee
Project Location: Knoxville, TN

Date of Report: 2010
Written by: Burton C. English

Task number: [(e.g., A)]
Task 1: What incentives are required to entice producers to grow switchgrass?

Develop a pilot study that establishes up to 120 acres of cropland in switchgrass and 20 acres on a TN Experiment Station Farm. This subtask would assess production of switchgrass within the state of Tennessee under a variety of conditions and topography through on-farm production totaling 120 acres. Farms would be selected to participate through a bid process. Costs of establishment and maintenance of the switchgrass would be covered. In addition, allowances would be made for covering land rent and providing a yield incentive. An information and education program would be provided to producers prior to the bid process to assist producers in their bid decision. Agronomic, logistic, energy conversion and farming system issues associated with commercialization of a biomass energy industry will be evaluated. Information on the opportunities for producing switchgrass as an energy feedstock will be extended

Actual Accomplishments:

a) Completed storage study – sampled bales through 500 days and sent samples to both Idaho National Lab and National Renewable Energy Lab for chemical analysis. Have yet to have received a complete set of wet chemistry analysis from NREL. Have an article in review.
b) Have developed yield functions for switchgrass and land quality based on experimental data. Published an article on this part of the project.
c) Established that producers will bid there land into a bioenergy program. The incentive required is approximately $50 a ton assuming $3.00 or less for corn (2004 dollars).

Patents: [A **cumulative** list of patents applied for or resulting from the award, including date of application and receipt of patent(s) and date and status of DOE notification.]

Publications / Presentations:

Larson, J. A., T. E. Yu, B. C. English, D.F. Mooney, and C. Wang. 2010. **Cost evaluation of alternative switchgrass producing, harvesting, storing, and transporting systems and their logistics in the Southeastern USA**. Agricultural Finance Review 70(2): 184 - 200.

Mooney, D.F., R. K. Roberts, B. C. English, J. A. Larson, and D. D. Tyler. 2010. **Is Switchgrass Yield Response to Nitrogen Fertilizer Dynamic? Implications for Profitability and Sustainability at the Farm Level**. Journal of Agricultural and Applied Economics 42(3):588.

Mooney, D.F., R. K. Roberts, B. C. English, D. D. Tyler, and J. A. Larson. 2009. **Yield and Breakeven Price of 'Alamo' Switchgrass for Biofuels in Tennessee**. Agronomy Journal 101(5):1234-1242.

Task 2: Estimate Industry Impact

Subtask 1: Conduct a study estimating the demand for switchgrass in Tennessee and the economic impacts that demand will have on the State's economy. In this subtask, the state's potential for producing switchgrass for energy production; including both co-fire and ethanol production will be ascertained. Transportation costs of biomass to the energy production facility will be estimated and incorporated. This will include impact analysis of economic benefits derived from an energy program. To identify amounts and locations of potential switchgrass production, ORIBAS, a model constructed through a joint ORNL/UT project, will be modified with data from Task 1 to evaluate availability of switchgrass for use by existing power generating facilities, for conversion to bio-oil, and for conversion to ethanol. Potential locations of the facilities will be identified through GIS modeling.

Subtask 2: Conduct national analysis utilizing information learned from the survey and determine the potential impacts a switchgrass feedstock industry will have on the nation's agricultural sector. POLYSYS, a national agricultural model, will be updated and the impact a national energy crops program will have on the agricultural sector in Tennessee and the nation reevaluated using information gained from the survey. Assess the economic and environmental costs and benefits of producing and using switchgrass for energy production and corresponding policy implications.

1) **Actual Accomplishments:**
   a) Converted POLYSYS from Fortran to GAMS
   b) Developed BioFLAME a successor to ORIBAS
   c) Evaluated Tennessee's potential to meet Biomass Demands using BioFLAME and identified potential locations. Information was used to secure $70 million of state money to commercialize switchgrass to ethanol production and to explore farmer incentives, feedstock supply chain, and conversion technologies.

Task 3: Conversion of Switchgrass to Energy through co-fire and conversion of switchgrass to bio-oil through pyrolysis.

1) **Actual Accomplishments:**

Analysis is completed and a summary of the findings has been initiated. Iowa State did not complete project designed, but did get us sufficient information to wirte up the results in a Journal. Based on the swichgrass co-firing tests, the following conclusions are made:

1. Samples of switchgrass harvested after frost had lower nitrogen content than the before frost samples
2. Grass nitrogen content did not appear to affect overall NOx emissions during these co-firing tests
3. NOx was slightly higher with co-firing than for coal alone. No difference was noted for NOx emissions co-firing before and after frost grasses.

4. For the same grass, moisture content did not appear to affect NOx emissions (range 18% to 26% moisture)
5. CO emissions co-firing before and after frost grasses were about the same. CO emissions with co-firing was slightly lower at full load and about the same at low load compared with coal alone.
6. Boiler efficiency co-firing grass was about 0.5% lower at full load and 1.0% lower at low load
7. Moisture accounts for about 0.3 efficiency points
8. Dry gas loss accounts for about 0.2 efficiency points (full load) to 0.7 points (low load)
9. Unburned carbon is about the same for co-firing and coal alone, perhaps less at full load
10. Efficiency with after frost switchgrass is equal to or higher than with before frost grass.
11. The modified switchgrass system was successfully operated for 30 minutes at 80% auger rate, suggesting that modifications to the system were successful in improving pneumatic transport system stability and reliability.

Publications / Presentations:

He, R. H., X. Ye, B. C. English, and J.A. Satrio. 2009. Influence of Pyrolysis Conditions on Switchgrass Bio-oil Yield and Physicochemical Properties. Bioresource Technology, 100(21), 5305-5311.

In review : **Effect of Co-firing Switchgrass on Combustion Behavior and Pollutant Emissions on a 60MW Pulverized Coal Boiler**