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Project Title: Generating Electricity with Biomass Fuels at Ethanol Plants

Contract Number: RD-56 Milestone Number: 1 Report Date: March 3, 2006

Reporting Period: October 16, 2005 to February 28, 2006

Milestone Description: First three-month reporting period

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Congressional District: Minnesota fifth (UofM Sponsored Projects Administration)
Minnesota fourth (UofM Biosystems and Agricultural Engineering)

Executive Summary

- Developed and executed Letters of Understanding with five cooperating ethanol plants
- Participated in the International Fuel Ethanol Workshop & Trade Show in Kansas City
- Authored a paper entitled “Biomass for Electricity and Process Heat at Ethanol Plants”
- Met with a group of researchers working on ethanol process co-products
- Held project kickoff meeting in early November to discuss processes and procedures, and to consider possible project adjustments to reflect changes in the 20 months since project proposal was submitted
- Submitted proposals for papers on project related work for professional and industry meetings this summer
- Developed project web site www.biomassCHPethanol.umn.edu
- Explored policies and alternatives for selling power to the grid in preparation for this portion of the analysis
- Started work on changes in architecture of the electronic workbook to accommodate the economic analysis for the project
- Visited cooperating plants
- Attended Focus on Energy seminar on industrial energy management
- Updated the approach to the feed stream, emissions, and ash characterization tasks to enhance the usefulness of the finished report
- Developed project management, accounting, and reporting protocols

Technical Progress

Prepared by
R. Vance Morey, Professor, Biosystems and Agricultural Engineering Department
Douglas G. Tiffany, Research Fellow, Applied Economics Department
University of Minnesota
and
Dennis L. Hatfield, Ethanol Team Leader, RMT Inc.

Activities Prior to October 16, 2005

Because the award was initially announced on August 31, 2004 the project team started preliminary activities in late 2004/early 2005 in anticipation that a contract would be signed early in 2005. Letters of Understanding for Collaborative Research were sent to five partner ethanol plants in February 2005, and signed agreements were received over the period of March 2 to May 23, 2005 (example attached). The partner plants selected represent a variety of ages, sizes, and technologies. The partner ethanol plants are:

- Agri-Energy, LLC; Luverne, Minnesota
- Chippewa Valley Ethanol Company; Benson, Minnesota
- Corn Plus, LLC; Winnebago, Minnesota
- Ace Ethanol; Stanley, Wisconsin
- Badger State Ethanol, LLC; Monroe, Wisconsin

Vance Morey and Doug Tiffany attended the Fuel Ethanol Workshop & Trade Show (FEW) in Kansas City, Missouri. There they visited with a number of ethanol company representatives and suppliers to talk about our project.

Vance Morey, Doug Tiffany and Dennis Hatfield authored a paper entitled “Biomass for Electricity and Process Heat at Ethanol Plants”, which defines the net renewable energy gains that are possible using biomass to generate electricity and process heat at corn dry-grind ethanol plants and estimates the potential annual energy costs/savings for such a plant. The analysis shows that net renewable energy values for corn dry-grind ethanol production meet or exceed previous estimates for lignocellulosic biomass ethanol production. The paper summarizes the rationale for the work that is proposed in the Xcel Energy RDF project. The proposed work includes defining the necessary technologies and then evaluating associated capital and operating costs for biomass combustion/gasification, emission control, biomass fuel handling, and electricity generation to determine overall economic feasibility. The paper was presented at the 2005 American Society of Agricultural Engineers (ASAE) Annual International Meeting in July 2005 and has been submitted for publication.

In early August we met with a group of University of Illinois and United States Department of Agriculture researchers working on increasing utilization of ethanol plant co-products to better understand the changes that might be occurring related to this potential fuel source. While the University of Illinois/USDA group is focusing on food and feed applications, the information they have collected is useful for this project in terms of understanding and predicting some of the fuel and emission characteristics of these co-products.

Activities Since October 16, 2005
University of Minnesota and RMT team members met in St. Paul on November 2, 2005 for a kickoff meeting for the project. We discussed processes and procedures and reviewed the original schedule and tasks included in the proposal submitted in March 2004. The team also met with key subcontractors for analogous discussions, and toured the organics-fired, electricity-producing combustion units at the Pigs Eye plant. The Pigs Eye units are of a type included in this project, albeit with somewhat different organic fuel.

As a result of the discussions on November 2, we decided to modify the original tasks somewhat to take account of new tools and expertise that are available to us through RMT. We now have access to models that will allow prediction of combustion performance, emissions, and ash characterization for various fuel feed stream and thermal conversion technology combinations. The modifications involve a more focused feed stream analysis and literature review coupled with modeling of alternatives. We believe that we can develop more useful information and recommendations with this approach compared to the original approach for the same total expenditures. All original tasks will be included, but there will be some modifications in the details.

We have submitted proposals to present results of the work at the International Fuel Ethanol Workshop & Trade Show (FEW) in June 2006 in Milwaukee, Wisconsin and the American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting in July 2006 in Portland, Oregon. The ASABE paper proposal has been accepted, but we have not yet heard the results for the FEW proposal.

The high natural gas prices experienced in the time since this project was first proposed have awakened many ethanol plants to the opportunities to utilize biomass in co-generation. We expect an eager audience for the conclusions of this study.

Summary of Tasks Listed under Milestone 1

- Agreements with UofM, RMT in place – (completed)

- Letters of understanding with at least 5 ethanol plants in place – (completed)

- Project website up and running – available to the public (UofM) – (completed) www.biomassCHPethanol.umn.edu available on March 1, 2006.

- Biomass coproduct stream results (RMT) – (completed).
  We evaluated the entire sampling plan to reflect changes in the industry over the last 20 months. This information impacts on the feed stream analysis and combustion options tasks scheduled this period as well as fuel processing, combustion tests, and emission tests tasks scheduled for the second 3-month period. Thus, work done on this task will contribute to work on the tasks that are listed under milestone 2.

  We found more data for corn stover than for ethanol coproducts (DDGS, DDG, DWG, syrup). No ultimate analysis information was found for ethanol coproducts. We will have ultimate, proximate, and heat content analyses performed for each coproduct sample to have

a complete and consistent data set. Ash analysis will include mineral oxides, fusion temperature, nitrogen, and trace metals. We will conduct similar analyses on a limited set of corn stover samples to confirm previous results and fill in several areas important for ash and emission analysis.

We (UofM and/or RMT) visited four of the five plants to discuss the project and arrange for sample collection. The fifth plant was visited prior to the start of the project. We have obtained samples of three co-product streams from each of the five plants and have sent samples of each of those streams to two different labs for analysis. We have also sent corn stover samples to the two labs for analysis.

- Preliminary analysis of feed streams (RMT) – (completed)
  We have reviewed available feed-stream fuel characteristic data from the literature and are starting to evaluate results from the laboratory analysis of samples from the five plants. Summary tables for some of the data we reviewed are included below.

Dry-Grind Ethanol Co-Products

Summary of University of Illinois data from nine dry-grind plants (% of dry matter).

Element	Statistic	Corn	Wet Grains	Syrup	DDGS
Nitrogen	mean	1.5	5.4	3.2	5.1
	range	1.4 – 1.6	5.1 – 5.8	2.2 – 4.8	4.8 – 5.3
Calcium	mean	0.0051	0.019	0.045	0.028
	range				
Iron	mean	0.0035	0.010	0.014	0.010
	range				
Potassium	mean	0.36	0.59	2.32	1.12
	range			2.0 – 2.6	
Magnesium	mean	0.11	0.18	0.69	0.35
	range				
Sodium	mean	-	0.045	0.024	0.13
	range				
Phosphorus	mean	0.29	0.54	1.52	0.86
	range	0.26 – 0.31	0.50 – 0.59	1.35 – 1.85	0.70 – 0.95
Sulfur	mean	0.13	0.48	0.74	0.58
	range	0.10 – 0.20	0.40 – 0.58	0.20 – 1.32	0.36 – 0.84
Zinc	mean	0.0019	0.011	0.013	0.011
	range				

Source:
Belyea, R.L., K.D. Rausch, and M.E. Tumbleson. 2004. Composition of corn and distillers dried grains with solubles from dry grind ethanol processing. Bioresource Technology 94:293-298.

The same paper includes ash estimates for DDGS of 4.3 to 5% of dry matter.

Data from University of Minnesota and Dakota Gold for DDGS (% of dry matter)

Element	University of Minnesota*		Dakota Gold
	mean	range	
Nitrogen	4.9	4.5 – 5.4	4.7
Calcium	0.07	0.02 – 0.51	0.04
Phosphorus	0.76	0.42 – 0.99	0.83
Potassium	1.00	0.45 – 1.33	1.19
Sodium	0.17	0.01 – 0.52	0.19
Magnesium	0.30	0.14 – 0.38	0.36
Sulfur	0.61	0.31 – 1.05	0.84
Chloride	0.19	0.12 – 0.36	--
Ash	6.0	3.0 – 9.8	4.2

* Data are for 32 plants in 11 states for all quantities except chloride, which is for 16 plants in 8 states.

University of Minnesota. 2005. The value and use of distillers dried grains with solubles (DDGS) in livestock and poultry feeds. Online: www.ddgs.umn.edu

Dakota Gold. 2005. Dakota Gold Marketing – Enhanced nutrition distillers products. Online: www.dakotagoldmarketing.com

Fuel Data for Selected Biomass Materials

AURI provides the following estimates for fuel data on a dry matter basis.

Product	Higher heating value Btu/lb	Ash, %	Sulfur, %
Corn	8100	1.23	0.13
DDGS	9422	4.59	0.45
DDG w/o solubles	9848	2.24	0.4
Corn stover/stalks	7768	7.64	0.04
Corn Cob	7911	2.32	0.04

AURI. 2005. Agricultural renewable solid fuels data. Agricultural Utilization Research Institute Fuels Initiative. Online: www.auri.org/research/fuels/downloads.asp

Data for corn grain, corn cob and corn stover

Product	HHV Btu/lb	Prox. Anal, % dry wt			Ultimate Analysis, %, dry wt						
		Vol.	Ash	Fix C	C	H	O	N	S	Cl	Ash
Corn	7395	86.57	1.27	12.16	44.00	6.11	47.24	1.24	0.14	-	1.27
Cobs	8070	80.10	1.36	18.50	46.58	5.87	45.46	0.47	0.01	0.21	1.40
Stover	7588	75.17	5.58	19.25	43.65	5.56	43.31	0.61	0.01	0.60	6.26

Source: Table 3.3, page 67. Brown, Robert C. 2003. Biorenewable Resources. Iowa State Press.

USDOE-EERE Biomass Feedstock Composition and Property Database
(data available for corn stover)
http://www1.eere.energy.gov/biomass/feedstock_databases.html

- Preliminary combustion options (RMT) – (completed)
  We have investigated several biomass conversion technologies, either recently implemented or proposed, to provide process heat at fuel ethanol plants. These include fluidized bed combustion, fluidized bed gasification with gas clean-up, and fixed bed gasification. We are starting to evaluate these technologies using a gasification combustion model to determine performance characteristics with biomass fuels.

- Preliminary analysis of power purchase agreements (UofM) – (completed)
  We explored policies and alternatives for selling power to the grid in preparation for this portion of the analysis. Fuel ethanol plants may emerge as attractive co-generation facilities capable of satisfying base-load requirements and qualifying for capacity payments during the key June-September period in Xcel's service area. The geographic distribution of these plants near areas of the region producing wind power is fortuitous. When wind output is poor in summer months, ethanol plant co-generation power can serve regional power loads and offer ethanol plants the chance to reduce their power demand from the grid during times of peak grid loads.

- Preliminary development of spreadsheet architecture (UofM) – (completed)
  We started changes in the architecture of the electronic workbook that will accommodate the economic analysis for using biomass to produce electricity and process heat in dry-grind ethanol plants. We have visited with partner plant Corn Plus to learn about the changes that facility has experienced in costs as it displaced natural gas with wet stillage (syrup). We also had contact with Sebesta-Blomberg, P.A. regarding their project to burn wood at the Central Minnesota Ethanol plant at Little Falls, Minnesota. Cost categories for biomass storage, pre-treatment, and ash disposal, as well as ancillary costs associated with the combustion/gasification technology, are included in the revised spreadsheet.

- Summary of project management activities, travel, etc. for period (RMT) – (described above, modest expenditures so far)

- Summary of project management activities, travel, etc. for period (UofM) – (described above, modest expenditures so far)