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Project Title: **Gasification of Alternative Fuels to Convert Waste Materials to Energy – Phase Two**

Contract Number: RD 3-77 Milestone Number: One Report Date: 11/14/08

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Congressional District: (Corporate office) 12

Congressional District: (Project location) 2

MILESTONE ONE REPORT

Executive Summary

This project is the next demonstrative step on the path to commercialization of gasification technology. To achieve the primary goal of this project, a WESI fixed bed gasifier will be installed to convert turkey litter, flock mortalities, and/or various other locally available biomass materials, separately or combined, to energy. The project will demonstrate a complete gasification system, a small micro-turbine that will generate electricity, and the auxiliary equipment determined to best meet the heat and power needs of the industry partner and the fuel. Throughout this project the primary goal is to improve the efficiencies of the technology and to increase the bottom line value for industry partners who would choose the gasification of biomass.

There are instances where electricity production is not the best utilization for the energy generated through gasification or when electricity generation alone cannot provide sufficient capital payback to make a biomass gasification project feasible. It will be valuable to have research from this demonstration project to prove the economics of other energy uses. This project is designed to determine as many benefits from the system as possible within a farm setting. The ability to demonstrate to industries that

produce or have available biomass residues that they can capitalize on these added benefits should be persuasive in promoting renewable energy as a best business practice.

Coaltec staff met at the project site in Northfield MN with John Zimmerman of P & J Product, and Mark Ritter, Project Manger for Xcel Energy's Renewable Development Fund, to discuss the requirements of the project, inspect the site, and kick off the project. P & J staff have finished the concrete pad where the system will be sited and have installed the electrical components required for installation of the system [photo in Appendix]. Additionally, the following milestones have been met: fuel analysis completed; energy needs of the farm completed; identification of permitting requirements completed; all necessary contracts are completed (Fuel Supply Agreement, Landlord/Construction Agreement, Westwood Engineering Agreement); preliminary engineering has begun. All completed milestones have met or exceeded the expectations stated in the proposal. The work completed to date puts the project ahead of schedule and will benefit the project as it moves forward. Especially valuable was the information gained regarding the Minnesota Pollution Control Agency permitting requirements, based on data from the RDF 2-77 project and other Coaltec projects, which was provided to MPCA for their decision making process.

Project funding provided by customers of Xcel Energy through a grant from the Renewable Development Fund.

Technical Progress

As stated, the project is ahead of the Critical Path Schedule. The following technical components of the project were accomplished during this milestone:

Fuel Analysis

There will be a variety of fuels used in P & J Products project, but the main component will be turkey litter. This material has been analyzed for 2 purposes; as a fuel for the gasifier, and for the potential nutrient value as either a dried product or as an ash from the gasification process. Coaltec performed substantial fuel analysis work under another grant funded project through Xcel and found very similar results. The energy content has considerable variability based on the age, handling and storage methods. The energy content is also dependent on the volume of wood shavings in the litter removed from the house. Ideally, the material will contain around 4,500 BTU/pound, with ash and moisture contents both ranging from 25 to 30%. This will vary based on a multitude of conditions, but the fuel will perform well in the gasifier down to around 3,800 BTU/pound, and marginally down to 3,500 BTUs. At this point either alternate fuels will be blended with the litter, or the start up propane burner will operate to supply additional energy. There are various fuels available on the farm, so blending is an easy solution – wood debris and corn stover are both available and make excellent blending fuels. The occasion use of the propane burner is also an easy solution as the automated controls will monitor the energy output and can immediately provide the necessary energy boost.

Poultry manure is a fairly difficult fuel to gasify. The density of the material requires more air and a longer retention time to react; therefore the throughput of the gasifier is reduced. P & J's fuel has enough wood in the litter to assist in the bed penetration, so the throughput is expected to be slightly higher than straight manure.

One of the most critical factors in the fuel analysis is the nutrient content. The feasibility of any commercial project is based on the economics, and the value of the ash is a huge component of the economics of this operation. The ash product from the gasifier will be a dry, granular material with concentrated nutrients. The Phosphorus and Potassium will be retained in the ash, and a percentage of the Calcium will also be retained. The level of these nutrients in the fuel ranges from 2 to 4%, but when concentrated in the ash will be close to 20%. There is a current value placed on the manure, which is lost as a revenue stream when the litter is used as a fuel. The increase in this value when the ash is produced is critical to provide adequate revenue to give the farmer a return on his investment. While the energy production is also important, much of the fuel blending and testing will be done to maximize the value of the ash as much as optimizing the energy output. The goal is to find the solution that provides the best in both areas.

The addition of zeolite in the feed for the turkeys should produce a litter that retains a higher percentage of nitrogen in the litter. One of the unknowns in this project is how the zeolite will react in the gasifier and how much, if any, of this nitrogen will

remain in the ash. If the ash value is as a feed supplement, the nitrogen value may not be as great as it will be if used as a fertilizer.

One of the truly unknowns in this project is the opportunity to produce biochar. One of Coaltec's other operations has attracted significant attention and is exploring the potential of producing an ash rich in carbon-char. That project is somewhat limited in the ability to experiment with the fuel as the feed for the birds is controlled by a major poultry integrator and they are unwilling to participate. There will be some experimentation on this project with the fuel blend to attempt to produce a high valued product containing biochar. At this point, the impact of some of the variables is unknown – the operation of the gasifier itself can be altered to produce a variable ash; but it is also expected that fuel blending may have an impact and will be trialed to determine the impact.

Composite Fuel Analysis

While the age of the litter and the volume of wood shavings have an impact on the quality of the litter, a composite analysis of various samples was calculated. The litter was analyzed for both energy content and nutrients, as the nutrient value is important in the ash evaluation. The analysis is:

	As Received	**Dry**
% Total moisture	31.5	-
% Volatile Matter	40.4	59.0
% Ash	16.2	23.6
% Fixed Carbon	11.9	17.4
% Sulfur	0.5	0.7
Btu/lb.	4082	5959
% Carbon	24.2	35.3
% Hydrogen	3.2	4.7
% Nitrogen	2.9	4.2

Nutrient Value – As Received
Nitrogen – 2.9%
P2O5 – 4.22%
K2O – 2.31%
Calcium – 4.76%

Energy Needs

As with most poultry operations the predominate energy need is heat. There is an electrical load to operate ventilation fans and lighting, but this is not a large impact on the business. The electrical bill for the farm will be in the order of $1,000 per month. The farm only has 110-volt service, so all electrical equipment is low voltage.

The heating needs of the farm are supplied by propane. This need is cyclic and varies as the needs of the birds' changes as they grow, and the outside temperature also impacts the volume of heat required. The cost of this energy also varies wildly and the cost of propane has not been very stable in the past few years. The maximum energy needs for one house will be about 1 MMBTU/hr. There are 2 houses in close proximity and can both be serviced easily by the gasifier. There are other options to utilize the energy on the farm – additional houses, grain drying, and manure drying; but they will require additional equipment or ducting.

Not only is the heat need the greatest energy need on the farm, it also provides additional benefits - both financial and environmental. The burning of propane in the houses produces water in the air. This moisture reacts with the nitrogen in the litter to produce ammonia. This is harmful to the turkeys and creates additional nitrogen in the form of ammonia being exhausted into the atmosphere. The heat provided by the gasifier will decrease the humidity in the houses; will provide a better, healthier environment for the turkeys; and will lower the ammonia emissions on the farm.

The electrical requirements of the gasifier system will be in the 75 to 100 horsepower range – this is dependent on the final design of the heat exchanger and ventilation system. The power consumption of the system will be partially offset by the lower need for operation the ventilation fans in the houses. The gasifier system will provide a positive air pressure in the house, thus reducing and in many cases eliminating the need for the fans to operate intermittently to ventilate the house.

Permitting Requirements

The Minnesota Pollution Control Agency Supervisor for Air Quality Permits, Unit 2 Industrial Division, stated that the project should not need to apply for a permit based on emissions numbers from previous testing at Coaltec's commercially-sized testing unit compared to the regulatory thresholds. The system has very low emissions and will most likely be a negative NOX emitter based on farm's current propane usage. Air emissions for the Coaltec system are below all Minnesota regulatory thresholds.

Contracts

All necessary contracts are secured and have been forwarded to Mark Ritter, Xcel Energy Project Manager for this RDF project. Contracts include the Landlord/Construction Agreement, Fuel Supply Agreement, and Engineering Agreement.

System Design

The following **Preliminary Engineering** work has been done.

The gasification system will consist of the following components:

- Heat exchanger
- Microturbine

- Air distribution system
- Gasifier:
    1. Fuel storage hopper
    2. Belt conveyor delivery system
    3. Fuel surge hopper and feed delivery system
    4. Primary gasifier unit
    5. Transition ducting
    6. Oxidizer
    7. Stack
    8. PLC controls and MCC building
    9. Ash removal system

While the design is not complete, the gasifier system design has been done. Following is the detailed design criteria for the gasification unit.

WESI-36 Gasifier Energy System

Gasification is a staged oxidation process designed to provide optimal energy and environmental performance. The reactions take place in a refractory line Primary Gasification Chamber and an Oxidation/Temp Control Chamber. The WESI-36 is a two-stage gasification system consisting of:

- (1) one reaction bed area including one 200,000 BTU natural gas or propane start-up burner;
- (1) one ash removal section and standard removal conveyor;
- (1) one oxidizer/temp control section complete with a 2MMBTU natural gas or propane start-up burner.

The WESI-36 process consists of two steps in the process of delivering useable heat to the customer's applications:

(1) Primary Gasification Chamber is where gasification of target fuel into producer gas takes place;

(2) Oxidation / Temp Control Chamber is where high temp oxidation and combustion of the produced gases as well as air dilution to desired temperature takes place.

The Primary Gasification Chamber is an oxygen starved (fuel rich) chamber that promotes the production of CO, CH4, and H2 at a relatively low temperature. A small amount of CO2 is created in the chamber to provide the energy for the gasification process. As the amount of moisture increases in the fuel, additional CO2 has to be produced to maintain the target temperatures. This balance is accurately maintained by controlling the air/fuel ratio in the primary chamber and the resulting "producer gas" is ducted to the Oxidation Chamber. The Oxidation / Temperature Control Chamber is a cylinder with staged air added in a directional manner. This produces a spinning reaction area that promotes an even blending of the combustible producer gas, created in the Primary Chamber, with additional air. As the gas reacts it produces heat energy and additional air is added to keep the temperature within the target range. VFD Air fans and air valves are controlled by temperature and provide exactly enough air for complete Oxidation of the producer gas plus enough dilution air to maintain target temperatures.

The throughput of the unit and energy output are partially determined by the fuel utilized. The system will gasify a fuel with energy content above 3,500 BTU/pound, and with a

lower grade fuel, will produce about 3 MMBTU/hr. of energy. The throughput of this unit again is determined by fuel; the fuel described will be consumed at a rate of up to 1000 pounds per hour. The rate can probably be turned down to 500 pounds per hour; again this is determined by fuel quality. The system has the capability of operating with the oxidizer propane burner providing intermittent energy to assist in consuming fuels that do not meet the required energy content. This is regulated by the automated control system.

This system comes with the following features:

-Heavy duty mechanical design for harsh environments
-Highly automated, simple and effective design providing reliable, consistent and high quality operations
- Great accessibility and visibility into the machine
- Allen Bradley control system (PLC) installed in a NEMA 12 cabinet with user-friendly interface
- Standard safety features such as: No Burn Back System, high temp shutdowns,
- alarms, high fuel bed controls/shutdown, downstream equipment failure shutdown, fuel piles monitor and control critical temperatures
- Standard and high quality components used throughout
- TEFC electrical motors
- Compact 'footprint' allowing easy integration into many site layouts

STARTUP BURNERS

System will be delivered complete with 2MMBTU per hour natural gas burner integral to the oxidizer/temperature control section as well as a 200,000 BTU natural gas burner integral to the primary section of the WESI-36 Gasifier System. Burner controls are integrated with the PLC. These burners are available for start-up as well as smokeless shutdown of the system.

WEB BASED REMOTE MONITORING AND OPERATING SYSTEM

The WESI-36 System comes with an internet-based SCADA monitoring and data collection application. The industry proven CitectSCADA automation platform provides remote access to current gasifier operational data, full equipment control, alarming logging, trending and report generation. Reporting features include total energy produced, total up time, total fuel consumed, total natural gas consumed as well as additional customer project specific information. Access to the system comes via a computer with internet connection running the CitectSCADA client application. Built-in software features, internet firewall equipment and strict login information provides a high level of plant access security.

AUTO ASH REMOVAL

An automatic ash removal system is supplied with the unit. It will remove a measured amount of ash by means of a live floor system that covers the base of the fuel bed. As the reacted material moves down through the gasifier primary chamber it drops below the air injection system and starts to cool. The cooler material is then removed by a timed activation of the floor and dropped into a conveyor.

STANDARD FUEL INFEED SYSTEM

Infeed System: This unit will come with an infeed system consisting of a loader feed hopper / side-metering system capable of storing 2-4 tons of fuel and will supply a measured amount of fuel to the feed ram as required. System will handle a product size less than 6 inches. System also includes an inclined conveyor to feed unit, plus an 8-ton storage hopper. Feed system controls are automated to feed unit as needed – will provide 16-hour operating storage capacity.

AUTOMATED CONTROLS

Full feature Allen Bradley PLC control system. Local Magelis Human-Machine Interface (HMI) provides complete control of all plant operations.
This system is set to a specific energy and temperature target that is controlled by the amount of the air injected into the primary reaction chamber. To further protect the operation of the gasifier a secondary mechanical method of stopping the fuel feed was added to the gasifier design. A high temperature arm extends a short distance in the primary chamber and rests on the top of the fuel bed. A proximity sensor on the control end of the arm prevents the overfilling of the gasifier chamber with fuel. As the bed reacts and reduces the size of the fuel bed the arms will drop and allow the introduction of more fuel.
Fuel feed automation includes sequential, interlocked operation of the feed system plungers and various chopper/metering systems which in turn will call for fuel from the customer's fuel handling system. The feed system is interlocked with the gasifier fuel-high signals to prevent overfilling the gasification chamber.
Ash system automation includes sequential, interlocked operation of the ash floor and ash removal conveyor as well as the customer's ancillary ash removal equipment.
Gasifier automation includes: static and modulating air fan controls, remote actuated valves, ACFM flow meters, all working together to maintain adequate fuel reaction rates and acceptable reaction temperatures.
Oxidizer automation includes: modulating air fan controls, remote activated valves, ACFM flow meters, all working together to promote complete oxidization of the producer gases as well as maintain acceptable delivery temperatures to the customer's applications.
Boiler or kiln inlet temperature control comes via automated modulation of the customer's 'pull through' ID fans as well as modulation and blending of fresh or re-circulated air from an outside louvered inlet or from pulling down the by-pass stack. This operation provides the proper mixture of air with the hot oxidizer air to maintain required boiler or kiln inlet temperatures.
High alarm limits as well as integrated tripping signals with end-user equipment provide safe, automatic bypass-to-stack or system shutdown controls for the gasifier if downstream equipment is not operating.

ENGINEERING, CONTROL INTEGRATION AND SOFTWARE

Engineering drawings will be created in AutoCAD format. All drawings submitted to the client will be in Adobe Portable Document Format (PDF).
Deliverable documents are:

- Electrical Single line Diagrams

- Electrical Three line Diagrams
- General Arrangement Diagrams of PLC and MCC control cabinets
- Electrical Control Wiring Diagrams for Gasifier cabinet and field wiring
- Wiring Cable Schedule
- Three (3) paper copies of all relevant equipment manuals
- Three (3) electronic copies of all relevant equipment manuals
- Plant Control Narrative delivered close to project commencement
- System Operations Manual delivered close to project completion

PLC programming software used for the project is Allen Bradley Compact Logix with PLC firmware version RS Logix 5000.

HMI programming software is Magelis XBT-L1000 V4.20 light for any alphanumeric screen included in the project. Touch panel programming software is GE Cimplicity Machine Edition Version 5.50 HMI programming suite.

Web-based remote SCADA access will be implemented using the CitectSCADA V6.0 automation platform. The data server will be running CitectSCADA Internet Display Server while the clients will use CitectSCADA Internet Display Clients.

Additional Milestones:

The system design is well along, including selection, specification, and costing of components. The preliminary engineering should be completed within the next month.

Project Status

The project is ahead of schedule and is within budget.

LEGAL NOTICE

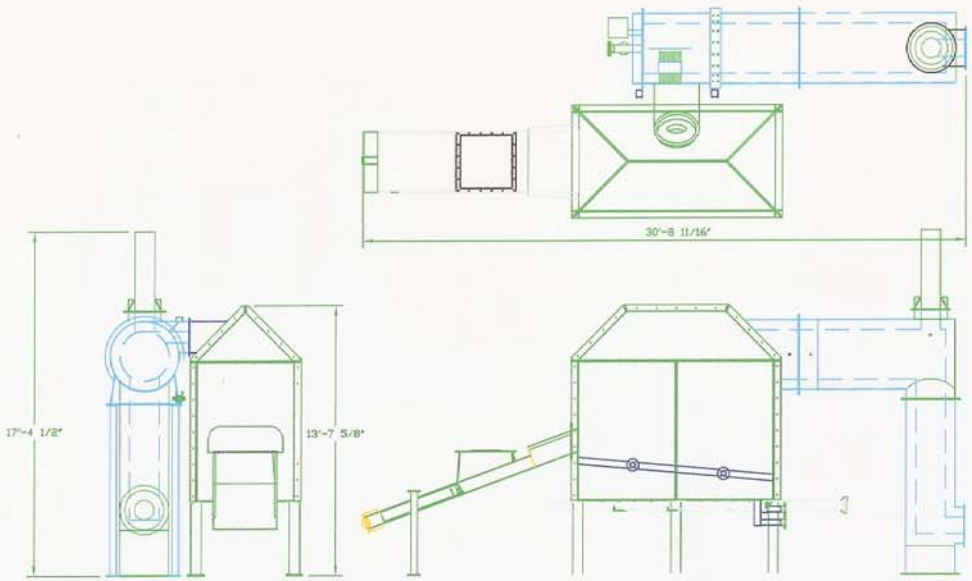
Appendix

Electric supply installed and concrete pad constructed at site for gasifier system at P & J Products

Following are photos of a similar system operating on a poultry operation in West Virginia.

Frye Poultry Farm, Wardensville, WV

Ducting running into one of three chicken houses



Gasifier Layout Diagram