July 30, 2009

Mr. Timothy Edman
Manager, Regulatory Administration
Xcel Energy, Inc.
414 Nicollet Mall
Minneapolis, MN 55401

Dear Mr. Edman:

Subject: Quarterly Progress Report Entitled "Indirect Liquefaction of Wood Waste for Remote Power Generation Fuel"; Contract No. RD3-66; EERC Fund 9968

Enclosed please find the subject report. If you have any questions, please contact me by phone at (701) 777-5159 or by e-mail at jhurley@undeerc.org.

Sincerely,

John P. Hurley
Senior Research Advisor

JPH/hmv

Enclosure

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Energy & Environmental Research Center University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Project Title:	Indirect Liquefaction of Wood Waste for Remote Power Generation Fuel		
Contract Number:	RD3-66	Milestone Number: 1	Report Date: July 30, 2009
Principal Investigator:	John Hurley	Contract Contact: Tobe Larson	
	(701) 777-5159	(701) 777-5271	
Congressional District:	Not Applicable		
Congressional District:	Not Applicable		

MILESTONE REPORT

Executive Summary:

During this milestone period, the three-dimensional modeling of the trailer-mounted indirect liquefaction system continued using the software program AutoCAD® Inventor. In addition, vendor quotes were requested for parts of the gas cleanup system and gas-to-liquid conversion system. As described in the last milestone report, the permit applicability request for the demonstration project in Minnesota has been submitted to the Minnesota Pollution Control Agency (MPCA). The project is still expected to be exempt from air quality permitting, but MPCA has not yet informed us of its decision. Laboratory testing of syngas conversion systems was initiated through the design of an experimental matrix as well as operation of a syngas reactor system to complete testing of approximately half of the matrix conditions by the end of the milestone period.

A new type of small gasifier technology is being developed and tested at the Energy & Environmental Research Center (EERC) under separate funding. The system is designed to handle high-volatile fuels but should also be able to handle the very wet, or green, wood which is one of the unique objectives of the gasification technology being tested under this program (RD3-66). One advantage of the new gasifier is that it is much more easily scaled up in size for situations where a system larger than can be mounted on a trailer is required. Also, its throughput can be much higher than with the thermally integrated system, allowing a higher overall system productivity. Therefore, we are planning to use a portion of the renewable development funds (RDF) project funds to perform a test in the pilot-scale system with wet wood chips collected from the proposed field demonstration site. The main goals of the test are to determine if, in fact, it can gasify wet wood, and if so, determine the maximum fuel feed and gas production rates as well as levels of contaminants in the product gas. These data will allow us to more accurately determine the best types and sizes of the components to be used in the trailer-mounted system. The test will take approximately 1 week. It is currently scheduled for completion by the end of August 2009. No additional project funds will be required for this test.

A formal lease agreement with Valley Forest Wood Products for siting the trailer-mounted indirect liquefaction system at its Marcell, Minnesota, pellet plant has been executed (Appendix A). The EERC is currently in the process of negotiating the subcontract with the University of Minnesota – Duluth (UMD).

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

Technical Progress:

System Design

The software program AutoCAD Inventor is being used to generate three-dimensional models of the components of the biomass gasification system. The individual component models, such as the gasifier, scrubber, feed system, etc., are being assembled onto a model of the truck trailer to determine the most suitable location and orientations for the process modules. Most modules will be assembled off of the trailer on skids and then moved into place, easing construction, repair, and substitution. We are postponing completion of the model because decisions about the size and exact types of gas cleanup modules will not be finalized until we can analyze the results of the testing of the new gasifier design (described in a following section of this report).

Requests for Vendor Quotes

The preliminary syngas cleanup system design consists of four major components. The first component is a cyclone separator for removing large particulate matter. One company (Imperial Systems®) estimated a price of $6000. Other quotes are still being pursued. The next component in the cleanup system is the ejector venturi scrubber, which sprays the gas with water to remove medium particulates and soluble gases (such as H_2S). Several companies (such as Advanced Air Technologies® and D.R. Technology®) have quoted total gas cleanup systems. These systems have ranged in price from $50,000 to $200,000. Price estimates for only an ejector venturi scrubber are forthcoming. The third component is an activated carbon filter bed or filter used mainly for removing volatile organic compounds (VOCs) and remaining sulfides. Carbtrol® provides easily changed modules that are rated for hazardous waste, which may be appropriate. A quote for this system is being pursued. The last component is a high-efficiency particulate, or HEPA, filter for removing fine particulate remaining in the gas stream. Pure Air Systems® provides industrial air filtration systems for $1200, with replacement filters for $250. Since a motor fan may not be needed, the filters could be purchased and a housing unit made in-house.

Quotes for the gas compression unit have been and are still being obtained to find a suitable option. Products from RIX, Fluitron, Ariel, HydroPac, and Maxpro have been investigated. Of these HydroPac, Maxpro, and RIX have determined they are unable to supply the required compressor effectively or economically. Ariel has said it can provide the required compressor and is working on a quote currently.

Site Lease Agreement and Subcontract Status

At the request of Xcel Energy, the EERC requested a more formal lease agreement than just a support letter from Valley Forest Wood Products for siting the demonstration system at its pellet plant near Marcell, Minnesota. A copy of the signed agreement is given in Appendix A. We have received a proposal from University of Minnesota – Duluth (UMD) for their work in the program. The EERC is currently in the process of negotiating the subcontract with the UMD.

State Permitting

Permitting for pilot work in North Dakota was completed, and a permit applicability request for the demonstration project in Minnesota was submitted during the previous milestone period. The project is expected to be exempt from air quality permitting from MPCA, but as of the end of the period, the decision is still not finalized.

Gas-to-Liquids Conversion

The methanol synthesis reactor for the project is currently being designed. As a first step toward finalizing the design, various reactor operating parameters and expected syngas composition

from the integrated biomass gasifier are being experimentally evaluated in a specially designed modular reactor system. A picture of the system is shown in Figure 1. It consists of three main subsystems: 1) a synthetic syngas supply system, 2) a methanol synthesis reactor and heat management system, and 3) a purge gas analysis system.

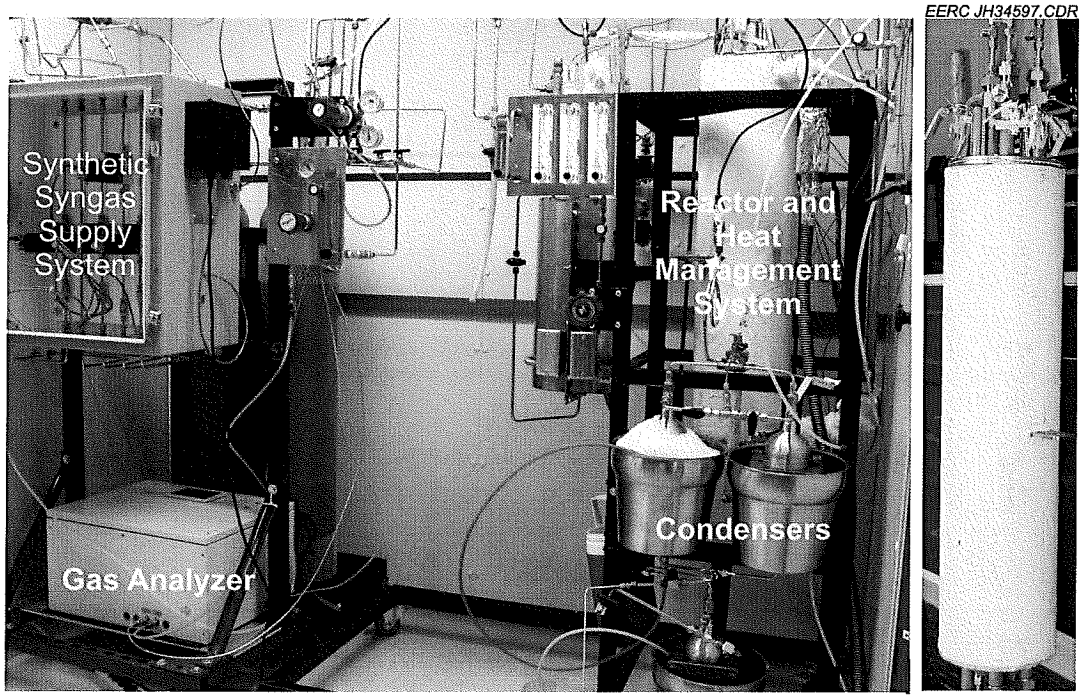

Figure 1. Syngas-to-methanol test setup showing syngas supply system, synthesis reactor, liquid condenser, and online gas analyzer.

During this quarter, parametric testing of the system was begun. After calibration of the mass flow controllers and gas analyzer to ensure that data for gas flows and conversion rates would be accurate, a $Cu/ZnO/Al_2O_3$ methanol synthesis catalyst was loaded into the reactor. A 2-week shakedown test of the reactor system with catalyst was done to determine that the temperature control of the reactor was adequate. The deactivation rate of the catalyst was monitored simultaneously.

In order to determine the optimum operating conditions of the reactor system to produce methanol, a five-factor central composite experiment of 34 runs was designed. If the system response exhibits linearity through the first block of 24 runs, then the experiment may be shortened. The partial pressures of carbon monoxide, hydrogen, carbon dioxide, and nitrogen will be varied along with the reactor temperature. As a result of independently varying the partial pressure of each gas, the H_2:CO ratio will change between 0.6 and 1.6, the concentration of CO_2 will change between 2% and 12%, and the concentration of N_2 will change between 18% and 42%. Total system pressure will differ between 300 and 600 psi, and temperature will vary between 200° and 300°C.

During the tests, replication of the center point run condition showed an unacceptable decline in catalyst activity that was not observed in the 2-week shakedown test. A periodic catalyst reactivation is required and will be conducted once per week. The first block of the experiments is 50% complete.

Additional Milestones:

Pilot-Scale Gasification Test

A unique aspect of the EERC indirect liquefaction system as it was originally proposed was the use of a thermally integrated gasifier that could use green, or wet, wood as a fuel. Green wood contains as much as 50% moisture, enough to quench the gasification reaction in a typical air-blown downdraft gasifier. Unfortunately, the method of thermal integration prevented upsizing the technology to much more than the size that could be mounted on a trailer. Since the proposal was written, however, a new gasifier technology is being tested at the EERC. The gasifier was designed specifically to handle fuels with very high volatile contents such as railroad ties. A pilot-scale version of the system has been built, and shakedown testing has been completed. The gasifier contains a very long and uniform reaction zone that should also allow it to gasify wet wood just as can the thermally integrated gasifer. One advantage of the new gasifier is that it is much more easily scaled up in size for situations where a system larger than can be mounted on a trailer is required. Also, its throughput can be much higher than with the thermally integrated system, allowing a higher overall system productivity. Therefore, we are planning to use a portion of the RDF project funds to perform a test in the pilot-scale system with wet wood chips collected from the proposed field demonstration site, the Valley Forest Wood Products pellet plant near Marcell, Minnesota. The main goals of the test are to determine if, in fact, it can gasify wet wood and, if so, determine the maximum fuel feed and gas production rates as well as levels of contaminants in the product gas. These data will allow us to more accurately determine the best types and sizes of the components to be used in the trailer-mounted system. The test will take approximately 1 week. It is currently scheduled for completion by the end of August 2009. No additional project funds will be required for this test.

The main components of the pilot-scale gasifier system include a fuel feed system, fixed-bed gasifier reactor, residue extraction system, syngas scrubber, induced draft (ID) fan, syngas exhaust system, and operating parameter monitor and control system. The general schematic of the gasification system is shown in Figure 2. The system is classified for Class 1, Division 2, Group B classification for the operation of electrical components in explosive gas environments. The nominal throughput of the biomass is 33 lb/h. The fuel is fed from the top of the gasifier with the help of an enclosed auger. The fuel hopper can store about 200 lb of biomass. The gasification air is injected from the top of the gasifier. The gasifier is equipped with a solid fuel igniter. The exothermic heat profile is established in the fuel bed soon after the ignition and steady-state gasification can be achieved within 30 minutes of the initiation of ignition, depending on the fuel moisture content and reactivity. The syngas leaves the reactor from the bottom of the gasifier. The syngas is scrubbed in a two-stage scrubber prior to exhausting it through the flare. The ID fan located at the downstream of the syngas scrubber maintains the pressure drop across all upstream components, including the gasifier and the syngas-scrubbing system. The positive pressure maintained at the downstream of the ID fan helps exhaust the syngas through the flare. The syngas flow rate is measured with the help of an orifice flowmeter located at the downstream of the blower. A similar arrangement is provided to determine the gasification airflow rate at the upstream of the gasifier. The flare system consists of a hot-surface igniter. The flare combustion air is induced by the ejector effect caused by the flow of syngas. A gas-sampling port is provided on the flare for determining exhaust emissions.

The clean syngas composition is determined using an online gas analyzer capable of measuring CO, CO_2, O_2, H_2, and CH_4. A separate arrangement is provided for sampling syngas for the determination of tar and particulate matter in raw or hot as well as clean syngas.

Project Status:

As noted in the last milestone report, the project is approximately 3 months behind schedule as a result of waiting for the construction and operation of the pilot-scale gasifier which employs a new and unique gasification technology that will be beneficial to this program (RDF3-66). However, it is expected that program system design, bidding of equipment, and purchasing of equipment listed for Milestone 2 will be completed during the Milestone Period 3 quarter, returning us to the correct time schedule by the end of project Milestone Period 4. Because of the delay, we are considerably under budget but expect rapidly accelerated spending as equipment is purchased during the third and fourth milestone periods.

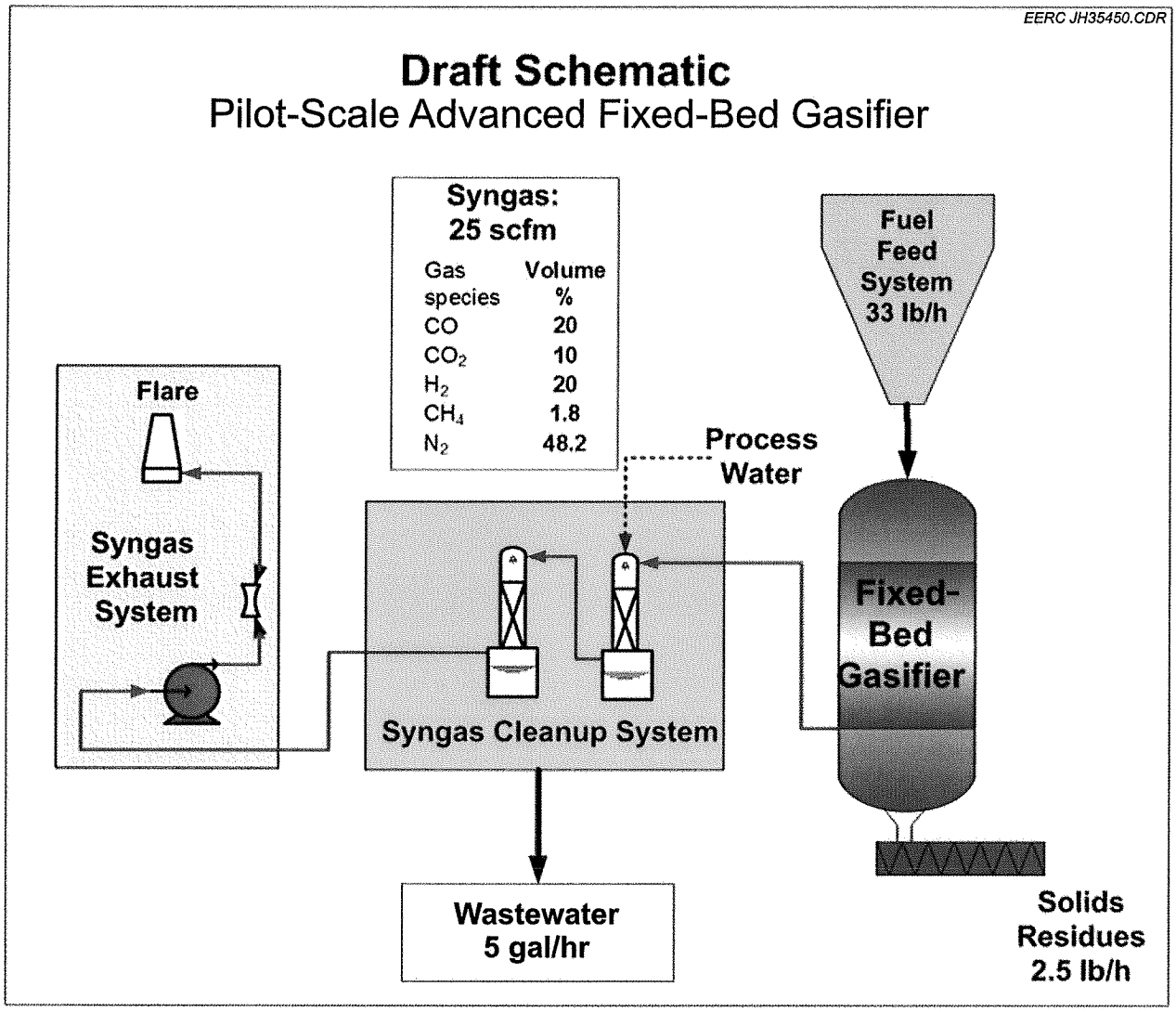

Figure 2. Process flow diagram for the EERC pilot-scale gasification system capable of using wet or high-volatile fuels.

Appendices:

Attached in Appendix A is a copy of the lease agreement between the EERC and Valley Forest Wood Products to allow us to site and test the trailer-mounted indirect liquefaction system at its Marcell, Minnesota, pellet-making plant.

LEGAL NOTICE