



EERC

Energy & Environmental Research Center

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December 13, 2011

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

Dear Mr. Edman:

Subject: Revised Milestone 6 Progress Report Entitled “Indirect Liquefaction of Wood Waste for Remote Power Generation Fuel”; Contract No. RD3-66; EERC Fund 9968

Please find enclosed the Milestone 6 report that has been modified as requested by Mark Ritter. 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/bjr

Enclosure

c/enc: Mark Ritter, Xcel Energy, Inc.



Energy & Environmental Research Center, University of North Dakota
15 North 23rd Street, Stop 9018
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Project Title: Indirect Liquefaction of Wood Waste for Remote Power Generation Fuel

Contract Number: RD3-66 Milestone Number: 6 Report Date: December 13, 2011

Principal Investigator: John Hurley Contract Contact: Tobe Larson

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Congressional District: Not Applicable

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MILESTONE 6 REPORT

Project funding provided by customers of Xcel Energy through a grant from the Renewable Development fund and the U.S. Department of Energy.

Executive Summary

Under RD3-66, the University of North Dakota Energy & Environmental Research Center (EERC) is testing a mobile system for converting wet wood into methanol. During this milestone period, the gasifier was operated by itself and in conjunction with the gas-to-liquid system for the first time. The catalyst used to make methanol from the syngas was activated, and methanol was also produced for the first time with the system. The methanol will be analyzed for moisture content, purity, and metals contamination during the next milestone period.

The gasifier was designed to handle approximately 200 pounds of wet wood per hour, but we believe, based on initial operation, that over 300 pounds of wet wood can be handled by the gasifier per hour. The system is currently being operated with chipped hybrid poplar purchased from Dukek Logging, obtained from a site near Regal, Minnesota. Moisture content in 1-pound samples has varied from 27% to 38%, which is far too wet for use in most commercial gasifier designs that can only handle partially dried wood. However, the mobile indirect liquefaction system (MILS) gasifier is uniquely designed to handle wood with this level of moisture.

For the initial methanol production tests, the product rate was 10–15 gallons per ton. This compares favorably with the model predictions based on the syngas composition and flow rate. However, it is significantly lower than the original estimate of 35 gallons per ton that we believe the system is capable of producing. The main factors contributing to the lower methanol production rate than what was originally predicted are a gas feed rate that is half of what was expected because of an underperforming syngas blower and lower CO and H₂ concentrations in the syngas produced from the gasifier. Although this production rate is low, several operational changes have been identified in order to increase production.

Technical Progress

System Design:

Figure 1 shows the general 3-D design of the MILS. The sizing of the gasifier, heat exchangers, and gas cleanup components is such that the system extends beyond the trailer roof height and so requires assembly in the field.

The indirect liquefaction process begins with the gasifier toward the rear of the trailer from which the gas will flow through a set of heat exchangers and wet scrubbers to clean it. After this stage, the gas is ducted toward the middle of the trailer, where it goes through another cleaning process and then to the compressor. The compressor pressurizes the gas to 900 psi, and then the gas flows through the gas-to-liquid reactor system. The control area is at the front of the trailer, shown by the enclosed box on the upper trailer. A picture of the MILS system is shown in Figure 2.

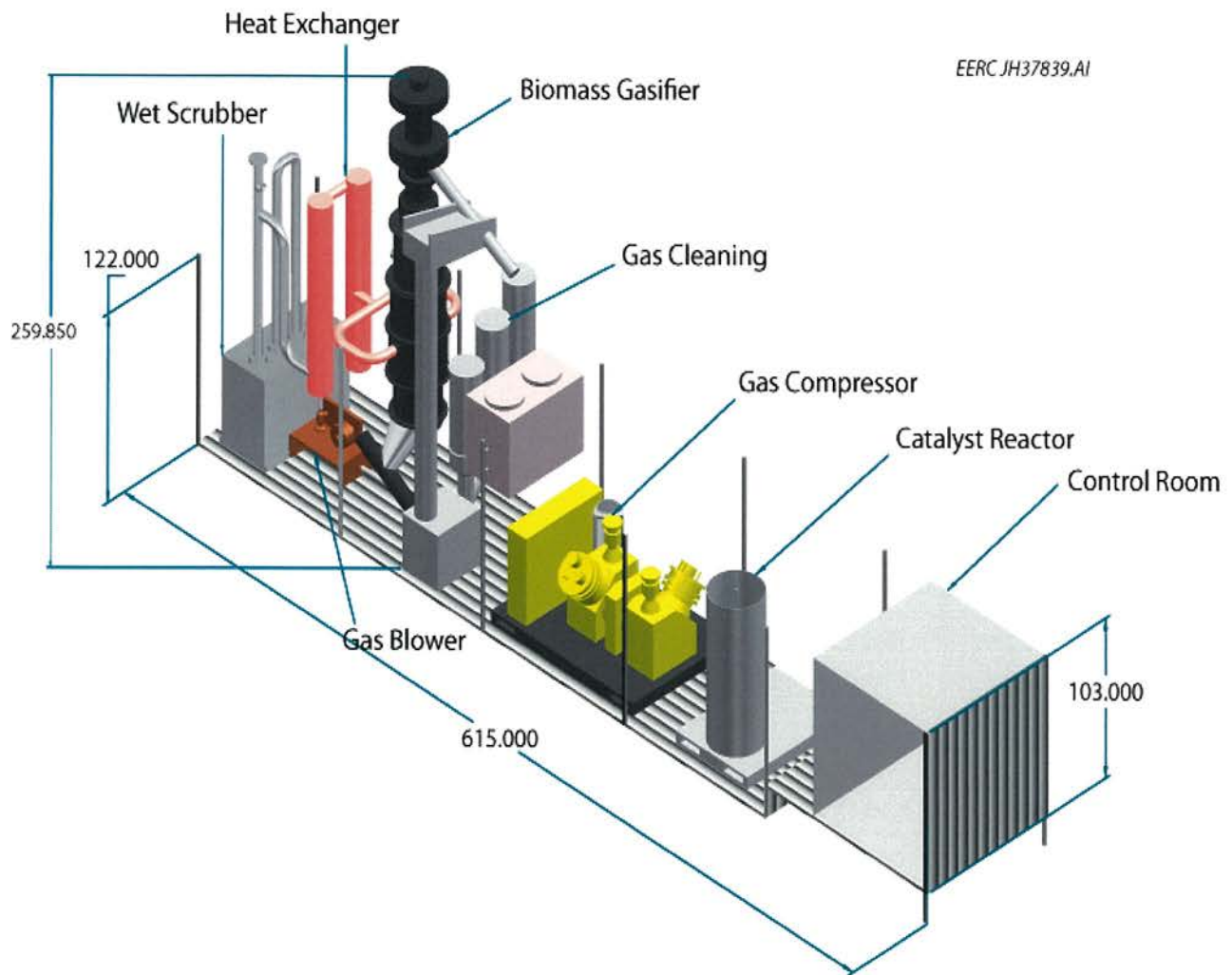


Figure 1. 3-D drawing of trailer-mounted gasification system. The trailer roof has been removed for this depiction only. Lengths are in inches.



Figure 2. The completed MILS system. The gas-to-liquid reactor is behind the trailer curtain.

Sensors and Controls:

The programming language for controlling the indirect liquefaction system is LabVIEW. This language has been used in both academic and industrial control applications. The EERC has prior knowledge and experience using LabVIEW for control applications.

The indirect liquefaction control system can be broken into two parts, a real-time controller (RTC) and a human machine interface (HMI). The RTC utilizes a real-time operating system that is more robust for control systems than a general operating system. Fail-safe logic and alarms are located on the RTC and inaccessible to the user to prevent tampering. The RTC sorts the various input and output controls and device communications.

Although the RTC is present in the system, the control of the system is being performed through the HMI, which allows an operator to monitor and control the system. This includes device control, data logging, real-time data trending, and system status and alarms. Noncritical system logic is located on this device.

Fuel Properties:

The system is currently being operated with chipped hybrid poplar purchased from Dukek Logging, obtained from a site near Regal, Minnesota. Moisture contents in 1-pound samples have varied from 27% to 38%, which is far too wet for use in most commercial gasifier designs that can only handle partially dried wood. However, the MILS gasifier is specially designed to handle wood with this level of moisture.

System Operation:

The MILS gasifier and gas cleanup system are shown in Figure 3. Figure 4 shows the conveyor that brings the wood chips to the top of the gasifier.



Figure 3. The MILS gasifier and gas cleanup system.



Figure 4. The conveyor used to carry the wood chips to the top of the gasifier.

The gasifier was designed to handle approximately 200 pounds of wet wood per hour, but we believe, based on initial operation, that over 300 pounds of wet wood could be handled by the gasifier per hour. During the first three weeks of November 2011, tests were conducted to understand the effects of different feed rates and the ability of the gasifier to adjust to the varying operating conditions. During these tests, wet wood was injected at the rates ranging between 150 and 165 lb/h. A total of 3300 pounds of wet wood was consumed during the milestone period. In addition to wood chips, about 310 pounds of wood charcoal was also consumed during the initial start-up. It was observed that the gasifier could generate combustible gas after an overnight shutdown of the system within 4 minutes of starting the air feed. The average syngas production rate was observed to have ranged between 80 and 95 scfm.

The gas compressor and gas-to-liquid conversion reactor are shown in Figure 5. In the initial system tests completed under Milestone 6, air temperatures were below freezing. Because of the cold weather, the heat-transfer fluid had solidified, and the reactor had to be externally heated to thaw the fluid. To prevent freezing, the oil pump and heater are now continuously operated. The methanol catalyst was activated under flowing hydrogen and nitrogen at concentrations of 10% and 90%, respectively. The reactor temperature was ramped up to 250°C for catalyst activation.

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Figure 5. The gas compressor and gas-to-liquid reactor.

For the initial methanol production test, syngas was fed to the methanol reactor at a flow rate of 75 standard cubic feet per minute and concentrations of CO 15%, H₂ 17%, CO₂ 15%, N₂ 50%, and hydrocarbons 3%. The methanol reactor was operated at 210°C and 900 psi. For the initial methanol production tests, the product rate was 10–15 gallons per ton. This compares favorably with the model predictions based on the syngas composition and flow rate. However, it is significantly lower than the original estimate of 35 gallons per ton that we believe the system is capable of producing. The main factors contributing to the lower methanol production rate than what was originally predicted are a gas feed rate that is half of what was expected because of an underperforming syngas blower and lower CO and H₂ concentrations in the syngas produced from the gasifier. Although this production rate is low, several operational changes have been identified in order to increase production. The methanol will be analyzed for moisture content, purity, and metals contamination during the next milestone period.

Project Status:

During this milestone period, the gasifier was operated by itself and in conjunction with the gas to liquid system for the first time. Methanol was also produced for the first time with the system. The methanol will be analyzed during the next milestone period. In addition, during the next milestone period, we will test a different wood source as fuel for the gasifier. We will also begin production of methanol for testing by IdaTech in a reformer of the type used in the operation of its fuel cell, which requires approximately 10 gallons of methanol for the tests that will take approximately 10 days to complete.

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