



October 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/kal

Enclosure



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: 3 Report Date: October 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 was switched from AutoCAD[®] Inventor to Siemen's Solid Edge because of its greater ease of use and ability to easily lay out piping runs. After comparing the requirements of the indirect liquefaction system to commercial semitruck trailer designs, a nationwide search was initiated for a used curtain-sided dropped-deck trailer that will serve as the mobile platform of the 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. During this reporting period, we received an exemption from air emission permit requirements for the field testing phase of the project (Appendix A).

During this reporting period, parametric testing of the methanol catalyst performance was continued. The testing is necessary because the commercial catalyst is designed for creating methanol from a synthesis gas stream made from natural gas that has a much higher hydrogen content than simulated biomass syngas which will be created in this program. A five-factor, central composite experiment of 21 trials was designed to complete a parametric study that will help develop an understanding of reactor and catalyst performance. The highest methanol yield will be one of the primary criteria for the selection of operating parameters. This approach is critical to arrive at a reactor design that can be integrated with the gasifier without requiring extensive gas balance equipment that is inevitable with most large-scale methanol synthesis processes. The testing has so far shown that syngas conversion rate and selectivity are most strongly affected by the hydrogen partial pressure (PP) and lower reactor temperatures. Product yields are often over 90% methanol, with approximately 5% water and 5% other oxygenated hydrocarbons.

A new type of small gasifier technology is being developed and tested at the Energy & Environmental Research Center under funding separate from the Xcel RD3-66 program. The system is designed to handle high-volatile fuels but should also be able to handle the very wet, or green, wood that is one of the unique objectives of the gasification technology being tested under 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 originally proposed thermally integrated system, allowing a higher overall system productivity. Therefore, during this reporting period, we used a portion of the program funds to pay for a test of the pilot-scale system with wet wood chips collected from the proposed field demonstration site. The main goals of the test were to determine if, in fact, the new gasifier design can gasify wet wood and, if so, to determine the maximum fuel feed and gas production rates as well as levels of contaminants in the product gas. Overall, the testing confirmed that the new gasifier design was well suited to the gasification of wet wood waste and will have a much higher throughput than the originally proposed thermally integrated gasifier. The high throughput translates into a higher liquid production rate for essentially the same amount of labor and capital cost. Therefore, this design will be adopted for the RD3-66 indirect wood waste liquefaction system.

Technical Progress

System Design: The software program AutoCAD[®] Inventor was being used to generate three-dimensional (3-D) models of the components of the indirect biomass liquefaction system. However, this software was found to be more difficult to use than expected, especially in showing piping and electrical runs. Therefore, during this reporting period, the data already entered were transferred to Solid Edge modeling software from Siemens. This software provides for both 2-D and 3-D modeling and includes a robust piping and assembly package suitable for larger and more complex processes. This software is more suited to this project and is also more reliable than the previous AutoCAD software. The individual component models, such as the gasifier, scrubber, feed system, etc., are being assembled onto a model of a truck trailer to determine the most suitable location and orientations for the process modules. Most modules will be assembled on skids and then moved into place on the trailer, easing construction, repair, and substitution. The Energy & Environmental Research Center (EERC) postponed completion of the design because decisions about the size and exact types of gas cleanup modules were not finalized until we ran pilot-scale tests of a new gasifier concept that permits more rapid gasification of wet wood than the original concept could allow. Those gasifier tests were completed during this reporting period and are described in a following section of this report. We are currently analyzing the results of the tests and will use that data to complete the design and begin ordering and constructing parts of the system over the next reporting period.

The modeling to date has included sizing of the components to fit on a semitruck trailer. The gasification, compressor, and gas cleanup systems have been modeled in the software. Because of size constraints, a drop-deck trailer was chosen in order to provide more internal height for large components. The floor of this type of trailer drops down to the rear of the hitch to provide an extra 1–2 feet of internal height. The preferred trailer type is also enclosed with a retractable tarp. This allows the system to be opened during warmer weather and construction phases or closed during colder weather. A curtainside drop-deck trailer can be seen in Figure 1. We are currently working with a trucking company and searching trucking sales publications to find a used trailer of this type for sale.



Figure 1. An example of a curtainside drop-deck trailer.

The compressor that is required for the gas conversion module must be sized to fit inside the trailer dimensions, along with the gasification and gas-cleaning modules. A search of commercially available compressor types showed that, for the pressure and volume of gas required for the liquefaction system, a piston-type compressor is most suitable because diaphragm, rotary, and centrifugal compressors cannot meet the requirements economically. Atlas Copco provides a piston-type compressor with six cylinders and three stages that will compress the gas to 600 psi at the desired flow rate. The compressor is the largest component of the system, taking up 10 ft of the length and almost the entire width of the trailer. The compressor has an included oil cleanup system to capture any lubrication oil that may leak past the seals of the pistons. Most other compressor companies are not able to provide for such a large volume and pressure requirement as needed by this system.

Subcontract Status: 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 UMD.

State Permitting: An exemption from air quality permitting has been received from the Minnesota Pollution Control Agency for gaseous emissions that will occur during site testing of the indirect liquefaction system next year near Marcell, Minnesota. The exemption letter is shown in Appendix A.

Laboratory Gas-to-Liquids Conversion Testing: 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 2. 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.

During this reporting period, parametric testing of the methanol catalyst performance was continued. The testing is necessary because the commercial catalyst is designed for creating methanol from a synthesis gas stream made from natural gas which has a much higher hydrogen content than the simulated biomass syngas that will be created in this program. The operating pressure of the system ranges between 100 and 1000 psig. It is designed to maintain a constant reactor temperature of 40°–300°C, achieved by direct as well as indirect heat transfer using air, nitrogen, and syngas as heat-transfer mediums. The synthesis reaction is mildly exothermic, and the heat management system ensures constant catalyst bed temperatures under steady-state operation. The maximum design syngas flow rate is 70 L/min. The initial parametric study will be conducted at flow rates of 4 L/min. These experiments will be conducted at operating temperatures and pressures ranging from 200° to 300°C and 300 to 600 psig, respectively. The syngas composition range is based on prior high-moisture biomass gasification data that are H₂=20%–35%, CO=20%–35%, CO₂=8%, and N₂=22%–52%.

A five-factor, central composite experiment of 21 trials was designed to complete a parametric study that will help develop an understanding of reactor and catalyst performance. The highest methanol yield will be one of the primary criteria for the selection of operating

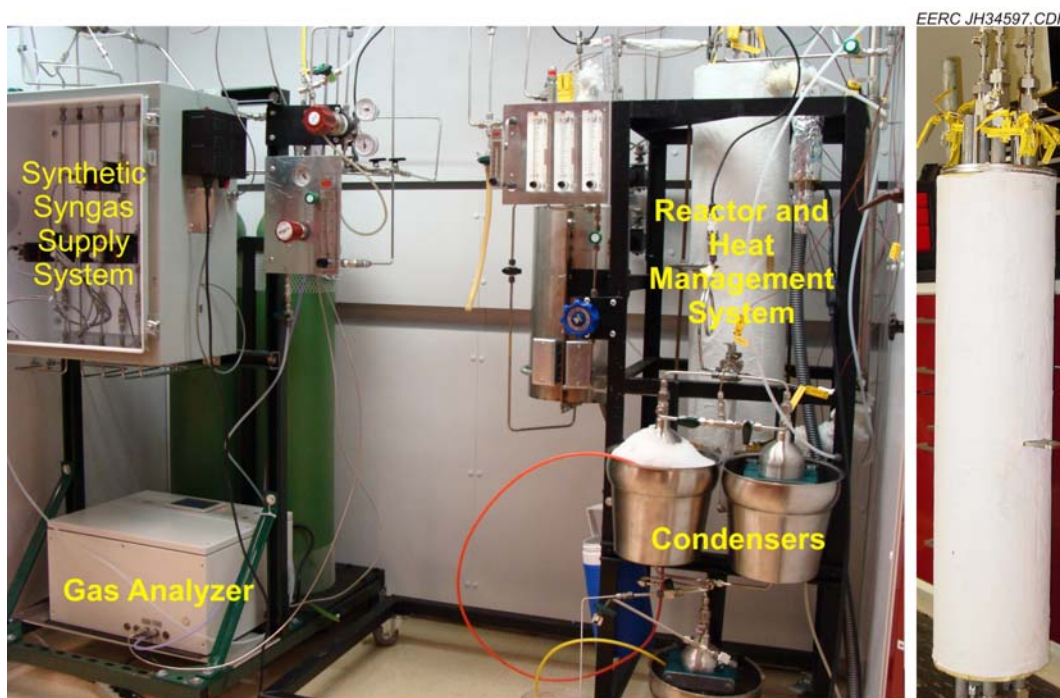


Figure 2. A syngas-to-methanol test setup showing a syngas supply system, synthesis reactor, liquid condenser, and online gas analyzer.

parameters. This approach is critical to arrive at a reactor design which can be integrated with the gasifier without requiring extensive gas balance equipment that is inevitable with most large-scale methanol synthesis processes.

The five factors studied in this experiment are listed in Table 1. The PPs of carbon monoxide, hydrogen, carbon dioxide, and nitrogen were independently varied along with the reactor temperature. Varying PPs rather than specific molar gas compositions at a given total pressure allows for independent control of all four gases. Total system pressure and gas compositions are then variables dependent upon the PP settings. The upper and lower limits of the PP of the gases were established so that the molar gas composition of hydrogen and carbon monoxide varied between 18% and 42%, nitrogen between 21% and 45%, and carbon dioxide between 3% and 12%. Total system pressure differed between 305 and 595 psi. The complete experimental design, which includes 16 factorial points with five center points, is shown in Table 2. The methanol productivity and selectivity for each run is also included.

The order of the trials was randomized, and several center point conditions were mixed in at regular intervals to determine catalyst deactivation rate. Data and product for each trial were collected during a period of at least 3 hours of steady-state operation. The catalyst was regenerated after every four trials, but it was determined during the experiment that the catalyst deactivates rapidly during the high-temperature trials. Because of this effect, some of the low-temperature trials were replicated.

The effects of the main factors and two-way interactions between factors were calculated and shown in Table 3. Statistical significance of the effects was determined from the variability observed from center point replication. Additionally, half normal plots of the effects were constructed to graphically verify significance. Reactor temperature (X5) was found to be the most important variable on methanol productivity and selectivity. Lower temperatures favor higher production and better selectivity to methanol. Hydrogen PP (X1) was the next most important variable. Higher hydrogen PP improves productivity and selectivity. The interaction between temperature and hydrogen PP (X1X5) was also a significant factor. The effect of hydrogen PP on methanol production rate was greater at low temperatures. Conversely, the effect of hydrogen PP on methanol selectivity was more important at high temperatures.

Somewhat surprisingly, the PP of carbon monoxide (X2) was not proven to be important for methanol synthesis. It should be noted that the calculated effects were near the cut-off for statistical significance. Regardless, the PP of carbon monoxide is not nearly as important as hydrogen. This could be an advantageous finding for reactor systems that use coal or biomass-derived syngas that have hydrogen to carbon monoxide ratios near one to one.

Table 1. Factor List with Coded Upper, Lower, and Center Point Settings

Factor	-1	0	1
X1: H ₂ PP, psi	95	125	155
X2: CO PP, psi	95	125	155
X3: N ₂ PP, psi	95	170	245
X4: CO ₂ PP, psi	20	30	40
X5: Temperature, °C	220	250	280

Table 2. 16 Run, Five-Factor Central Composite Experimental Design with Center Points

Run Order	Trial	Coded Design					Dependent Variables					MeOH Productivity, g/hr	MeOH Selectivity, wt%	
		X1	X2	X3	X4	X5	Total Pressure	H ₂ , %	CO, %	N ₂ , %	CO ₂ , %			H ₂ :CO Ratio
10	1	-1	-1	-1	-1	1	305.0	31	31	31	7	1.00	0.41	64.1
18	2	1	-1	-1	-1	-1	365.0	42	26	26	5	1.63	5.98	93.8
11	3	-1	1	-1	-1	-1	365.0	26	42	26	5	0.61	2.80	88.7
3	4	1	1	-1	-1	1	425.0	36	36	22	5	1.00	1.58	84.7
19	5	-1	-1	1	-1	-1	455.0	21	21	54	4	1.00	3.15	93.5
7	6	1	-1	1	-1	1	515.0	30	18	48	4	1.63	1.02	86.4
16	7	-1	1	1	-1	1	515.0	18	30	48	4	0.61	0.26	47.7
6	8	1	1	1	-1	-1	575.0	27	27	43	3	1.00	6.86	92.8
21	9	-1	-1	-1	1	-1	325.0	29	29	29	12	1.00	2.05	84.5
14	10	1	-1	-1	1	1	385.0	40	25	25	10	1.63	1.34	73.8
2	11	-1	1	-1	1	1	385.0	25	40	25	10	0.61	0.31	50.0
13	12	1	1	-1	1	-1	445.0	35	35	21	9	1.00	8.40	93.9
20	13	-1	-1	1	1	1	475.0	20	20	52	8	1.00	0.07	60.0
15	14	1	-1	1	1	-1	535.0	29	18	46	7	1.63	3.68	91.2
4	15	-1	1	1	1	-1	535.0	18	29	46	7	0.61	3.57	93.5
22	16	1	1	1	1	1	595.0	26	26	41	7	1.00	1.19	62.0
1	17	0	0	0	0	0	450.0	28	28	38	7	1.00	4.35	80.4
5	18	0	0	0	0	0	450.0	28	28	38	7	1.00	3.12	90.5
9	20	0	0	0	0	0	450.0	28	28	38	7	1.00	2.78	84.9
12	21	0	0	0	0	0	450.0	28	28	38	7	1.00	2.99	79.9
23	23	0	0	0	0	0	450.0	28	28	38	7	1.00	2.82	85.7

Table 3. Calculated Effects of Main Factors and Two-Way Interactions for Methanol Productivity and Selectivity

	MeOH Productivity, g/hr	MeOH Selectivity, wt%
X1	2.2	12.1
X2	0.9	-4.3
X3	-0.4	-0.8
X4	-0.2	-5.4
X5	3.8	-25.4
X1X2	0.6	1.3
X1X3	-0.8	-2.6
X1X4	0.0	-3.9
X1X5	-1.2	9.2
X2X3	0.1	-4.5
X2X4	0.7	1.7
X2X5	-0.8	-5.7
X3X4	-0.5	1.9
X3X5	0.1	-3.3
X4X5	0.1	-3.9

The higher PPs of carbon monoxide would have little-to-no effect on the production and selectivity of methanol. However, at similar system pressures, the additional carbon monoxide decreases the PP of hydrogen, which will hurt catalyst performance. Therefore, a methanol reactor that processes syngas with a one-to-one ratio of hydrogen and carbon monoxide will have to be designed to operate at a higher total pressure to achieve similar production rates as a system that processes syngas with higher hydrogen content.

The experimental design was analyzed for curvature, and it was determined not to be statistically significant. Therefore, the 16 factorial trials provide enough data to adequately describe the system. Mathematical models that are based on temperature and PP of hydrogen were created for each response. Contour plots were generated to show how methanol production rates and selectivity responds to changes in temperature and hydrogen PP (Figures 3 and 4). It is clear that both productivity and selectivity are maximized with increasing hydrogen PP and decreasing temperature.

The analysis of data for gas conversions yielded somewhat vague results. This likely stems from the fact that at least five competing reactions exist in this system (Table 4.) All reactions are exothermic, but a relatively wide disparity in heats of reaction exists. Therefore, from a thermodynamic perspective, reactor temperature should have a significant effect on gas conversions and product selectivity.

It has been made clear that temperature is the most important variable that affects the productivity and selectivity of methanol, and for the most part, the same holds true for the

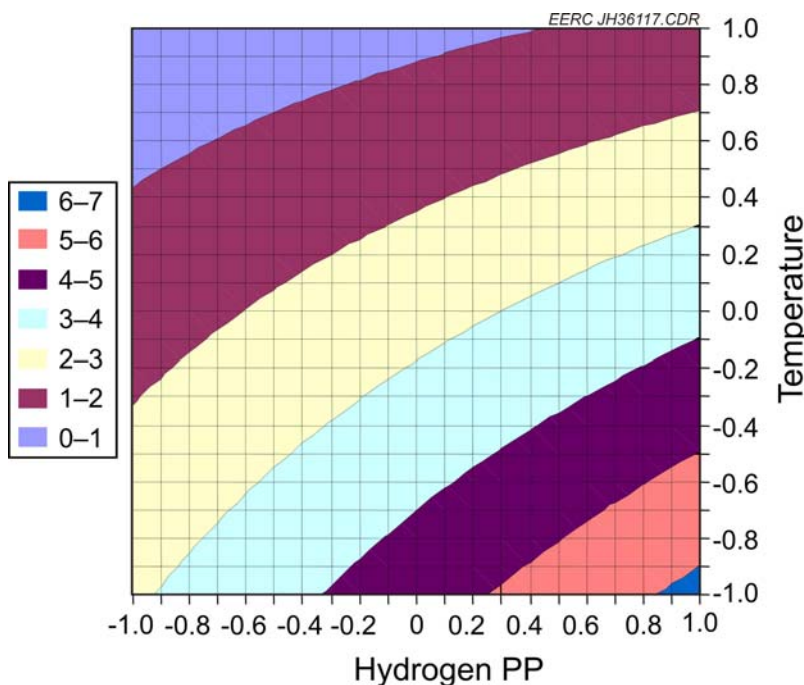


Figure 3. A contour plot of methanol production rate (g/hr) as a function of hydrogen PP and temperature.

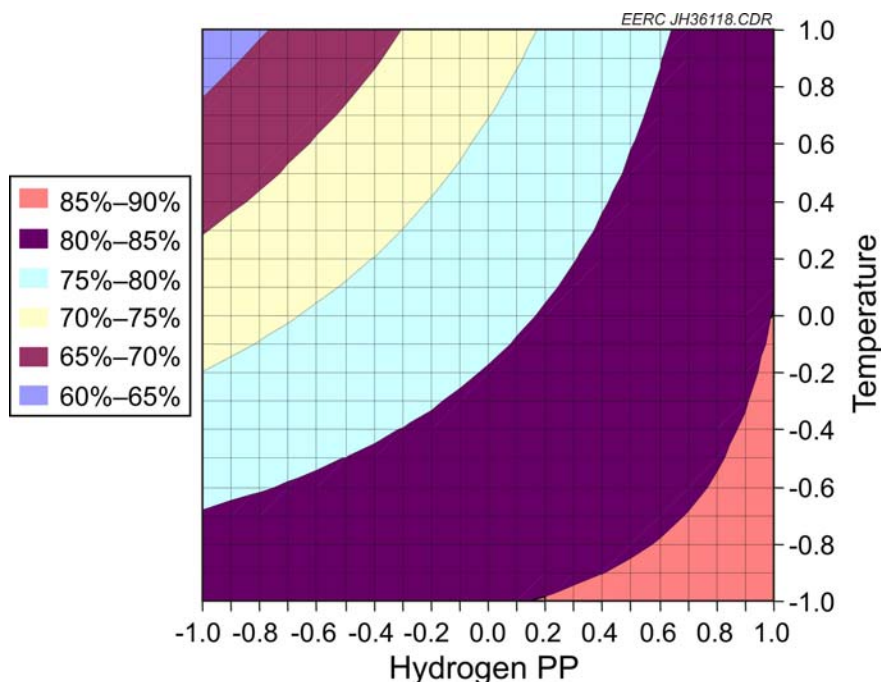


Figure 4. A contour plot of methanol selectivity (wt%) as a function of hydrogen and PP of hydrogen.

Table 4. Competing Chemical Reactions with Heats of Reaction

Water–Gas Shift	$\text{CO} + \text{H}_2\text{O} \leftrightarrow \text{H}_2 + \text{CO}_2$	–41 kJ/mol
Methanol	$\text{CO}_2 + 3\text{H}_2 \leftrightarrow \text{CH}_3\text{OH} + \text{H}_2\text{O}$	–49 kJ/mol
Methanol	$\text{CO} + 2\text{H}_2 \leftrightarrow \text{CH}_3\text{OH}$	–91 kJ/mol
Fischer–Tropsch	$\text{CO} + 2\text{H}_2 \leftrightarrow \text{-CH}_2\text{-} + \text{H}_2\text{O}$	–165 kJ/mol
Methanation	$\text{CO} + 3\text{H}_2 \leftrightarrow \text{CH}_4 + \text{H}_2\text{O}$	–217 kJ/mol

conversion of gases. It was clear from the data that increasing temperatures increases conversion of CO but decreases that of CO₂. At higher temperatures, more CO is being converted to CO₂. However, it was unclear if any variables were significant in affecting the conversion of hydrogen. At higher temperatures, more H₂ will also be created, but this extra H₂ is likely being converted to light hydrocarbon gases via the Fischer–Tropsch (FT) and methanation reactions. This is thermodynamically unfavorable, but the kinetics of the catalytic reaction may be increased at higher temperatures. Kinetic rate expressions are unavailable for this particular catalyst to accurately model the effects of temperature and PPs.

Future activities involve determining the deactivation rate of the catalyst at the optimum operating conditions of high hydrogen PP and low temperature. Also, a follow-up experiment will be conducted, which will focus on the low reactor temperature setting of 220°C and higher carbon dioxide PPs. Recent data from gasifier testing indicate that the syngas will likely have a higher composition of carbon dioxide than originally thought. The design of the trailer-mounted

methanol reactor will begin in earnest with a better understanding of syngas composition from the gasifier and the effects of higher CO₂ PPs are determined.

Additional Milestones

Pilot-Scale Gasification Test

System Design: In the original proposal for this project, the EERC described a unique biomass gasification system that, unlike other biomass gasification systems, would permit direct gasification of wet or green wood without the need for predrying. In addition, the gas produced has a higher hydrogen concentration than that produced from other small-scale gasifiers, making it especially suited for conversion to liquid fuels. Since the time of the proposal, however, the EERC has developed a new gasifier concept that has the potential to maintain these unique properties but, in addition, could allow for much more rapid throughput and easier system scale-up. Funding from other sources was recently used to construct a pilot-scale version of the new gasifier concept. During this reporting period, RD3-66 funds were used to pay for a test of the gasifier using wet wood to prove the suitability of the design for this indirect liquefaction project. The tests were very successful, so the new gasifier concept will be adopted for RD3-66.

The specifics of the gasifier design are currently confidential, pending the completion of the patenting process. However, we can give a generalized description of the system. The main components of the gasifier system include a fuel feed system, fixed-bed gasifier reactor, residue extraction system, syngas scrubber, induced draft (ID) fan, syngas exhaust system, and an operating parameter monitor and control system. 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 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 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 downstream of the blower. A similar arrangement is provided to determine the gasification air flow rate 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, CO₂, O₂, H₂, and CH₄. 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.

Green biomass obtained from forest product-processing units or those from legacy piles of wood-processing units typically contain about 35%–40% moisture, or possibly higher in a few other cases. The role of moisture in a self-sustained gasification process is to lower gasification

efficiency and syngas quality (calorific value) as a result of lowering of the gasifier bed temperature coupled with increases in contaminant concentrations in the syngas. The EERC's advanced pilot plant gasifier is based on a staged-air gasification process that allows the reacting fixed bed to achieve a long and uniform high temperature such that the gasification reactions achieve the highest carbon conversion while achieving a high H₂/CO and CO/CO₂ ratio, which is favorable for the liquid synthesis process. Achieving these features in the gasifier are critical for maximizing the liquid yields, while reducing or eliminating unconverted char discharge from the system, which is typically a liability, particularly for the technology designed to operate on green biomass at remotely located sites where residue disposal is not viable.

As was determined in an earlier feasibility study, maintaining a uniform high temperature in the reacting bed is critical for achieving a favorable gas composition for methanol (or FT liquid) production. The high moisture in the fuel could be used as a gasifying medium for increasing the hydrogen content of the syngas. The desired temperature profile could be provided either by indirect heat transfer to the reacting bed (thermal integration) or by direct heat transfer achieved by managing the hydrodynamics in the reacting bed. The latter approach is utilized in designing the advanced fixed-bed gasifier because of the ease of managing heat transfer in a large diameter gasifier bed. The advantage of this approach, opposed to the indirect heat transfer one, is the ability to achieve a radial as well as axial uniform temperature profile. This is critical for the kinetically controlled endothermic gasification reactions in maintaining desired syngas compositions. The advanced gasifier design is capable of achieving a uniform bed temperature even in the case of a large bed and helps achieve a near-complete carbon conversion. The small size of the gasifier is an additional feature critical for the mobile biomass-to-methanol system. The advanced gasifier is capable of operating at nearly twice the throughput rate compared to the originally proposed design.

System Test Results: The forestry residue expected to be processed in the mobile biomass-to-methanol production process will be low in energy density primarily because of a high-moisture content and partial natural decomposition. Tests of wood waste from the Marcell, Minnesota, plant show that the moisture content of the fuel can range from 30% to 55%. Preliminary gasification experiments were, therefore, conducted on wet wood waste obtained from three different sources. The three sources are a saw mill located near Marcell; a truss plant located in Grand Forks, North Dakota; and the Grand Forks Municipal wood disposal site. The moisture level of the waste wood from the truss plant was elevated to greater than 35%, while the inherent moisture levels of the wood from the saw mill and the municipal disposal site were 35% and 50%, respectively. A total of five gasification experiments on the wet wood consisted of a large fraction of fines were conducted for the duration ranging from 7 h to 24 h and at a conversion rate of 50 lb/h, which was about 50% higher throughput as compared to its nominal throughput of 33 lb/h.

The following are the summary results of the preliminary tests conducted on these fuels.

Steady-state gasification experiments were conducted to establish a long duration operation of the gasifier at near-constant flow rate and composition. Table 5 shows the average syngas composition for a 14 h average from the steady-state gasification test.

Table 5. Average Syngas Composition

Test Date: November 22, 2009	CO	CO ₂	CH ₄	H ₂	N ₂	C _x H _y	Higher Heating Value, MJ/m ³
Average Concentration, vol%	12.1	14.1	1.5	17.2	50.3	0.5	12.1
Standard Deviation	2.2	1.8	0.4	2.8	2.6	0.2	2.2

The gasification efficiency achieved for the high-moisture biomass was 80%, which means that only 20% of the calorific value of the wood waste was lost to system heat or emissions. The ratio of weight of gas produced to wet biomass fed during steady-state operation was 2.6. Short duration steady-state experiments were conducted to observe the range of H₂ and CO achievable. Table 6 shows a single measurement value.

Table 6. Single Measurement Value

Test Date: November 11, 2009	CO	CO ₂	CH ₄	H ₂	N ₂
Highest Concentration, vol%	22.8	8.4	1.36	37.4	30

The gasifier could be operated at two steady-state conditions such that the syngas composition with either high CO or high H₂ concentrations could be obtained (H₂/CO ratio of 0.25 and 1.8). The gasifier operating condition for achieving a higher H₂/CO ratio is selected for long duration steady-state operations for the liquid synthesis process. Nearly 100% carbon conversion could be achieved in the gasifier bed except for a small fraction of carbon recovered during the test in order to determine its gas adsorption capacity.

A test was conducted to determine particulate concentrations in the syngas stream following U.S. Environmental Protection Agency Method 5. The measurement indicated that the installed scrubber system was capable of removing about 85%–96% of the particulate matter. The gravimetric tar determination in the hot and scrubbed syngas was conducted during unsteady or transition gasifier operation. It was found that the scrubber system could remove about 93% of the tar during the worst-case operating conditions. In addition, the concentrations of sulfur species in the syngas were low. Both hydrogen disulfide and carbonyl sulfide were typically below 1 part per million on a volume basis.

Overall, the testing confirmed that the new gasifier design was well suited to the gasification of wet wood waste and will have a much higher throughput than the originally proposed thermally integrated gasifier. The high throughput translates into a higher liquid production rate for essentially the same amount of labor and capitol cost. Therefore, this design will be adopted for the RD3-66 indirect wood waste liquefaction system.

Attached to this quarterly is a copy of the letter from the Minnesota Pollution Control Agency stating that the trailer-mounted indirect liquefaction unit will not need an air quality permit for operation near Marcell, Minnesota, during the field trials of the system next year.

LEGAL NOTICE

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Minnesota Pollution Control Agency

520 Lafayette Road North | St. Paul, MN 55155-4194 | 651-296-6300 | 800-657-3864 | 651-282-5332 TTY | www.pca.state.n

July 14, 2009

Mr. Darren D. Schmidt
Energy & Environmental Research Center
15 North 23rd Street – Stop 9018
Grand Forks, ND 58202-9018

RE: Revised Applicability Request for a Temporary Operation Research Project of a Fuel Production Wood Gasification System Located Near Marcell, Minnesota

Dear Mr. Schmidt:

The Minnesota Pollution Control Agency staff has reviewed your April 7, 2009, Applicability Request. The Applicability Request is regarding the determination of whether an air quality permit is necessary for your proposed wood gasification project to be located near Marcell.

You have provided that the proposed project would involve the operation of a temporary portable liquid fuel production system. The system would comprise of a wood gasification system that would produce a synthetic gas for the conversion to liquid fuels. The only emission point would be a process gas flare. Fuel for the proposed project would be primarily softwood chips. No treated or adulterated biomass is permissible for fuel (i.e., treated lumber). You have also provided that the potential emissions would be below the thresholds for needing an air quality permit.

Therefore, based on the information that you have provided, the proposed project does not need an air quality permit for the described project. The facility should maintain the information demonstrating that an air permit is not required on-site.

If you have any questions or comments, please feel free to contact either myself, or Bruce Braaten, of our staff. Bruce Braaten can be reached at 507-206-2607 or via e-mail at bruce.braaten@pca.state.mn.us. I can be reached at 651-757-2285 or via e-mail at paula.connell@pca.state.mn.us.

Sincerely,

A handwritten signature in blue ink that reads "Paula Connell".

Paula J. Connell, P.E.
Supervisor, Air Quality Permits Unit 2
St. Paul Office
Industrial Division

BCB:lao

cc: Bruce Braaten, MPCA, Rochester
AQ File No. 4405

