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Biomass Gasification: A Comprehensive Demonstration of a Community-Scale Biomass Energy System

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Chapter 5: Permitting Processes and Procedures

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1. Contributors

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2. Pre-Project Testing and Feasibility Studies

Section I discusses in detail, the history of the project and the UMM permitting process. This section touches upon that process, but also includes ongoing operations and procedures. It has also been written for an audience exploring the potential of agricultural biomass gasification. In the preplanning stage for the University of Minnesota, Morris Biomass Gasification Plant, a Corn Stover/Corn Ethanol Mash Gasification test was commissioned from Coaltec Energy USA, Inc., Carterville, IL, in January of 2005 for Recovered Energy Resources, LLC (RER) on behalf of UMM. In the final report compiled by RER, dated March 30, 2005, several findings demonstrated the feasibility of the project and helped the MPCA permitting process move forward. The test system was a commercial-size gasifier rated at 25 MMBTU/hr. (7.32 MW(th)). The following summary presents the results used by the project team to determine the expected emissions and ash quality from the system.

The test and subsequent report included:

- Sustained operations using corn stover and corn stover mixed with ethanol mash
- Heat and mass balance to estimate system efficiency
- Emissions monitoring
- Fuel analysis
- Ash analysis
- Identification of issues, opportunities, and expected solutions and/or costs associated with those issues.

2.1 Summary of Initial Findings

While it was not expected to answer all questions about project feasibility, the goals of the testing were to gather reliable emissions data, identify any fatal flaws in the project, and develop a list of issues to be addressed in the system design should the project move forward. A brief summary of the findings follows:

- The measured rate of burn was approximately 35 lb. of fuel per square foot of available bed area, which was in the expected range for this fuel.
- Material handling of corn stover was successful. The stover was reduced in size in a tub grinder. A test in October of 2004 had shown that the in-feed system could not handle the stover in larger, variable pieces.
- In subsequent testing of the feed system with an alternative vertical auger, corn stover was moved successfully in all size ranges.
- Control of harmful emissions was generally successful. While the overall results were excellent, there are still a few issues that must be addressed.

- The ash material did not clinker and caused no handling problems.
- The efficiency of corn stover gasification was 99.6%, calculated as the percentage of fixed and volatile carbon that was converted.
- The system operated easily with the different fuel mixtures, without constant adjustment of the air flow and fuel feed rates. The ash quality did not present any environmental concerns.
- The air flow into the gasifier must be better controlled than it is now.
- The fuel feed system handled the ground fuel for this test. The horizontal feed augers could not maintain the required feed rate with unprocessed stover. A smaller vertical auger with a square housing was able to handle the unprocessed stover with no difficulty. A commercial system could use either the square-cased augers or a hydraulic ram system.
- Expected fuel throughput rates were achieved. It is apparent that commercial feed and ash handling systems can be designed and implemented. A particulate plume was not visible at the stack, but the fine filters did capture some material. This particulate entrainment is thought to be the result of fines created by the hammer mill grinding and the high rate of air flow required by the high moisture content in the fuel. In commercial application, the feed system would be designed so the grinding of the fuel would not be required; therefore, the amount of fines would be much lower.
- The stack emissions contained a high concentration of HCl. System design must consider the presence of chlorine and its removal. Minnesota regulations require us to control HCl.

2.2 Emissions Summary

Emissions sampling and analysis were performed by GE Energy. The gas stream was tested for CO, NO_x, SO_2, HCl, particulates, CO_2, and O_2. The stack emissions throughout the test were generally very low. The CO and CO_2 levels were very good, and the NO_x levels were within operating parameters. It was noted by Coaltec that the NO_x levels were dramatically reduced as the reaction temperature was lowered. The NO_x emissions at 1800° F were 50% of the emissions at 2000° F.

The major issues with emissions were identified as particulate matter and HCl. These issues are discussed in section 2.3.

2.3 Emissions Issues

Particulate matter. While there was no visible plume from the stack, a significant amount of particulate matter was captured by the test filters. There are several possible causes for this phenomenon, and several possible remedies. Particulate matter carryover is not typically an issue in gasifiers of the test gasifier's design. Two factors probably contributed to the particulate carryover seen in this test: 1) grinding the fuel in a hammer mill produced a large quantity of fines, and 2) the high moisture content of the fuel required more air flow than normal in the inner cone. Changing the feed system to eliminate grinding will dramatically lower the fines content. Improved air flow control in the cone will improve the efficiency of the conversion process, thus

requiring less total air to mitigate the effects of high moisture fuel. A bag house is certainly a viable option, as is a wet scrubber. These particulate removal systems are expensive and should only be employed if the previously mentioned remedies do not work or are impractical to deploy.

Hydrochloric acid (HCl). The chlorine content in corn stover is considered very high. The stover tested here assayed at 0.52% chlorine on average. Chlorine volatilizes easily and will be a potential emissions problem as it forms hydrogen chloride gas that is emitted from the stack if no control effort is undertaken. There are several issues and potential control strategies:

- The chlorine content of the fuel used in this test may not be consistent with the chlorine levels in corn grown in West Central Minnesota. Testing should be done to determine the chlorine content in any potential fuel stock. It may be possible to add a fuel specification in fuel purchase contracts that limits the acceptable level of chlorine in the stover.
- Another challenge is the great variability of chlorine concentrations in any give set of samples assayed. GE reported that in samples of fuel used in this test, the difference from lowest to highest samples was greater than two-fold. This variability suggests that some type of fuel monitoring should be considered in plant operations.
- The chlorine content of the ethanol mash was 0.14%. The mixture of 75% stover and 25% mash produced much lower HCl emissions than did 100% stover.

3. Permitting Processes and Procedures

With the passage of the federal Clean Air Act (CAA) in 1963, the United States federal government entered into regulation of interstate air quality. The act also provided federal research dollars and encouraged the creation of state control agencies.

The second amendment to the CAA, passed by the U.S. Congress in 1970, granted the federal government powers to set limits or standards for the quantity of various air pollutants certain sources can emit. After the establishment of the Environmental Protection Agency (EPA) in December of 1970, the major responsibility to prevent and control air pollution at its source fell to the states. For a state to conduct certain air quality programs, the state must adopt a plan, submit it to the EPA, and obtain their approval. This federal review and approval process provides for some consistency in different state programs and ensures that each state program complies with the requirements of the CAA and EPA rules. For the purposes of this report, the State of Minnesota Pollution Control Agency (MPCA) and EPA Region 5 will be referenced unless otherwise stated.

In Minnesota, the protocols and procedures for demonstrating compliance with the CAA and EPA rules are contained in the State Implementation Plan (SIP). Established as part of Title I, Section 110 of the CAA, the SIP

adopted by the state and approved by the EPA is legally binding under both state and federal law. Federal and state authorities use these regulations to enforce the requirements of the CAA.

The bulk of Minnesota's SIP includes site-specific emission limits as part of plans necessary to achieve and maintain the National Ambient Air Quality Standards (NAAQS). The SIP, located at http://www.pca.state.mn.us/index.php/view-document.html?gid=2239 also includes state air quality rules necessary for supporting the air quality program and maintaining the NAAQS. In Minnesota, the MPCA is responsible for the implementation of the SIP. UMM and the MPCA were in communication over several months and solved multiple issues related to plant startup and operations. Working with the University's air emissions consultant, three main areas were discussed:

Plant startup- The UMM gasification facility was issued permission to begin operations using corn stover, for which we had prior emissions data (RER 2005 Report, see above), wood chips and/or prairie grass. This permission was granted provided we submit emissions data that demonstrate that we are remaining under the emissions levels in the currently issued UMM air quality permit.

Testing of feedstocks- Standard MPCA protocols for the performance testing of the thermal conversion of different feedstocks are designed for large scale facilities that rarely change feedstocks. As a small applied research facility, the University's situation has challenged the MPCA to find protocols that fit the scale and needs of a small to medium size gasification facility as opposed to much larger generators. See Section I Chapter 3 for results of our fuel tests.

Ash handling and distribution- The MPCA regulates both the storage and dispersal of ash in quantities larger than the regulatory threshold. The UMM facility will be producing more than 10 tons annually and is therefore subject to regulation by the MPCA. Provided the ash is not contaminated with hazardous compounds, the MPCA rules are fairly flexible on dispensing ash. Prior to any use as a fertilizer or liming agent, gasification ash must be analyzed. Storage is also regulated to prevent runoff or contamination of soil, air, or water. Ash composition data are presented in Section 3. As of this writing, UMM is preparing its application for a Beneficial Use Determination from MPCA.

As the facility neared completion, UMM and the University consultant completed MPCA paperwork and discussed different issues with MPCA staff regarding the necessary permits and permissions for any potential pollutants. This process was fully completed when the plant became fully operational in winter of 2011.

MPCA Permits and Offsets 7007, Permits and Certifications, can be found under the Minnesota Administrative Rules at https://www.revisor.mn.gov/rules/?id=7007. UMM is regulated under 7007.1130 and we have an Option D registration permit. We must follow the National Emissions Standards for Hazardous Air Pollutants (NESHAPS, 40CFR63).

Note that each state's pollution control regulatory agency acts on behalf of the EPS in that state. States follow EPA regulations, but may have extended, strengthened, or added to the EPA regulations. YOU MUST CHECK WITH YOUR OWN STATE'S REGULATORY AGENCY. For reference, MPCA Fact Sheet aq4-04, "Facts About State Performance Test Rules" (in effect since December 1993), summarizes Minn. R. 7017.2001 to 7017.2060. These statutes "contain the notification, reporting and quality-assurance requirements for facilities that must conduct performance tests." The fact sheet can be found at http://www.pca.state.mn.us/index.php/view-document.html?gid=405.

Wet scrubber – UMM uses a conventional wet scrubber system for removal of fine particulates from the flue gas stream. The rated efficiency of the scrubber is 95%. The third-party testing done by Pace Analytical shows that our scrubbed particulate emissions average from 0.49 to 0.75 lb./hr. Comparison with a worst-case un-scrubbed measurement showed that the scrubber was operating at about 72% efficiency. Even at 72% efficiency under a worst-case condition, the annualized particulate emission would total less than 5 tons per year from the stack. This is well below our regulatory cap of 50 tons/yr.

We also use the scrubber for control of HCl by injecting NaOH (sodium hydroxide) into the scrubber water. The injection rate of NaOH is controlled by a feedback loop based on the pH of the scrubber water. The system keeps the pH of the return water between 6 and 8. Based on the testing done by Pace Analytical, in stack tests for all fuels, the HCl emission levels were <0.05 ppm. Given a calculated potential emission of up to 11 lb. /hr., or approximately 600 ppm. From this limited testing it appears that the NaOH injection into the scrubber water is better than 99% effective.

4. MPCA Process and Requirements

UMM was able to call upon the services of University of Minnesota MPCA liaisons to navigate the process of obtaining an emission permit for the existing heating plant. The MPCA website, with publications and applications specifically related to air emission regulations in Minnesota, can be found at http://www.pca.state.mn.us/index.php/air/air-publications/air-publications.html. As stated earlier, these are the Minnesota's SIP requirements as approved by EPA region 5. The EPA web site related to this process is located at http://www.epa.gov/region5/air/sips/index.html.

The purpose of the following subsections is to outline tasks required of UMM or recommended during start-up and operation as they pertain to air emissions from the new biomass boiler. The information is only for Minnesota and is specifically targeted to installations eligible to operate under a State Option D Permit. This section is broken into subsections that correspond to: the type of regulatory requirement, the regulatory period covered by the requirement, and the compliance method.

UMM's permit is a new source permit on an existing facility. All UMM emission sources operate under a State Option D Registration Permit. MPCA Option D registration permits are the most flexible and require the least reporting of all air emission permits they issue.

4.1 Annual Emission Thresholds

To remain eligible for Option D, the campus must have actual total annual emissions less than the thresholds shown in Table 1. (Also shown is the annual NESHAPS threshold for hydrochloric acid (HCl), which cannot be exceeded without triggering new permitting, emission controls and reporting requirements for the campus.) Table 1 presents three categories of emissions for the facility:

- Maximum Hourly Potential to Emit, Uncontrolled Emissions (lb /hr. - no air pollution control), based on chemical analyses of the fuel (corn stover in this case).
- Projected Annual Emissions, Uncontrolled.
- Projected Annual Emissions, with control technology operating.

Emission calculations are based on test data collected by the Canada Centre for Mineral and Energy Technology (CANMET) in 2007 and pollution control efficiencies provided by the equipment vendor. As indicated, the new biofuels plant will exceed emission thresholds if operated without air pollution control equipment. The controlling pollutants are HCl and particulates (PM) – which are controlled by the wet scrubber – and nitrogen oxides (NO_x), which are not controlled by the scrubber.

Table 1. Comparison of Estimated Emissions and Option D Thresholds

	Uncontrolled		Controlled		Option D	NESHAPS
Parameter	(lb/hr)	(tons/yr)	(tons/yr)	Control Equipment Efficiency	Maximum (tons/yr)	Maximum (tons/yr)
NOx	9.99	34.98	34.98	0%	50.00	N/A
HCl	8.50	29.77	1.49	95%	5.00	10.00
Particulate	8.08	28.28	1.41	95%	50.00	N/A
Fuel lb/hr	3,000	-	-			
Fuel hr/yr	-	7,000	7,000			

Note: Uncontrolled HCl emissions were much higher than expected based on the reported fuel content.

5. Performance Testing

The MPCA requires that the operator undertake several tasks to assure ongoing compliance with Option D, including testing, recordkeeping and reporting. The frequency of these tasks is determined by the tested emission rates compared to regulatory requirements. Each of these requirements and the test frequency plan is discussed below. While the boiler/scrubber is old and proven technology, it is here being used in a new application (agricultural residue as fuel). Thus the MPCA required the University to conduct emission tests to ensure that actual performance meets or exceeds expectations. Performance tests must be conducted periodically for each biofuel type, with the following tasks required before, during and after each performance test:

5.1 Test Plan Submittal

Must be done at least 30 days prior to the test dates. A Test Plan Application and Approval Letter will be part of this process.

5.2 Pretest Meeting with MPCA

Pretest meetings are usually held by telephone. UMM's Emissions Technician spoke by telephone with Sean O'Connor, Pollution Control Specialist at MPCA on 19 January 2011. O'Connor had a few questions. These questions were answered to MPCA's satisfaction and the Test Plan Approval Letter was sent to UMM on 20 January 2011.

5.3 Performance Test

The performance test was conducted by Pace Analytical Services of Minneapolis, MN, an independent and EPA-certified laboratory. The boiler was operated at or near in-feed capacity for each fuel during the tests. Testing dates were 25-26 January 2011 for prairie grass and 8-11 March 2011 for corn cobs and a mixture of 75% corn cobs and 25% ground corn stover.

5.4 Test Report

A test report must be submitted, incorporating all data required by state rule, within 60 days of test completion. The full UMM biomass facility report comprises 58 pages of narrative plus 435 pages of appendices. A compact disc copy of the test report is also required to be submitted to the MPCA.

The test results are discussed in section I, chapter 3 of this report.

5.5 Test Frequency Plan

The test frequency plan indicates when the next performance test is required. The frequency is based on the tested emission rate compared to regulatory requirements. The frequency can range from one year to five. As of this writing, UMM and its regulatory liaison are in conversation with MPCA about the test results. No decisions regarding permitting change or other requirements have yet been made.

6. Option D Permittees

As the UMM Biomass Gasification Plant is an Option D permittee, we may operate our emission units subject to performance testing. Unless we demonstrate that pollution control measures are working and at accepted levels, we must report as if there is no pollution control until regulatory testing is performed. (In the case of the biomass boiler, controlled pollutants are HCl and particulates). However, testing is not required until after the completion of initial startup. Note that while many states have a permit category such as Option D for small operations, you must check with your state's regulatory agency.

Generally, the MPCA allows an initial start-up period for the operator to "shake down" the system. Testing is usually required within 60 days of achieving maximum capacity or 180 days of initial startup, whichever is shorter. In addition, the permittee is allowed to request a testing delay due to a lack of steam demand (Minn. Rules 7007.1400, Subpart 1.H.).

In the case of the biomass boiler, the University requested to delay regulatory performance testing until winter 2011. Summer testing would require all steam to be vented and the engineer has stated that the unit does not have the capability to run for days while venting steam.

Testing by an independent laboratory was begun in late January 2011. Results were reported to the MPCA and are discussed in depth in section I, chapter 3 of this report.

7. Reporting & Recordkeeping

The following records and reports are required as part of the registration permit. There may be changes to our reporting requirements after MPCA has completed its review of our test results. At present, our reporting requirements under Option D are as shown below. Samples of the UMM reports and forms can be found in Section I: Chapter 4 of this report.

8. Annual Emissions Inventory

Emissions are calculated from fuel use and chemical composition of the fuel.

8.1 An Annual Emission Fee

Due every April 1, this is assessed based on actual emissions at a rate of approximately $31.50/ton and is paid to the MPCA.

8.2 Operation & Maintenance Plan

An operation and maintenance plan is required for pollution control equipment and emission-related boiler operation. The plan must be maintained on site. The plan must follow manufacturers' recommendations and include forms for routine inspections, scrubber pressure drop, shutdown and breakdown notifications, and unscheduled maintenance activities. The plan for the UMM Biomass Gasification Plant can be found in section I, chapter 2 of this report.

8.3 Monthly Fuel Consumption

Daily fuel consumption (and/or deliveries) must be recorded. It is recommended that daily steam production also be recorded in the same spreadsheet.

8.4 Semi-Annual Deviations Report/Annual Compliance Certification

These reports provide information regarding deviations from normal operating conditions and/or confirm compliance with permit conditions.

9. New Source Performance Standards (NSPS, 40CFR60, Subpart Dc)

9.1 Commercial-Industrial-Institutional Boilers

The biofuels boiler is subject to federal New Source Performance Standards. However, since the unit capacity is 19 MMBTU/hr, performance testing is not required for purposes of federal approval. (The performance testing threshold is 30 MMBTU/hr). Notifications, reporting and recordkeeping are still required.

9.2 Notification

The University must send a notification of Initial Startup to the MPCA and U.S. EPA Region V (postmarked) within 15 days after "such date" (40CFR60.7(a)(3) and 40CFR60.48c).

9.3 Reporting & Recordkeeping

Records of startup, shutdown and malfunctions (air pollution control and boiler), including date and duration must be maintained on-site. Any malfunction or other deviation from permit conditions must be reported on either the semi-annual deviations report (state requirement) or the annual compliance certification. A record of fuel supply (by delivery), including the suppliers' names, fuel type, potential sulfur emissions and the method used to determine the potential sulfur emission rate (wood only) must be maintained. Daily steam production should also be recorded.