



Source: Water & Light

Agenda Item No: REP 122-13

To: City Council
From: City Manager and Staff

Council Meeting Date: Aug 5, 2013

Re: MFA Oil Biomass Miscanthus Test Burn Report

EXECUTIVE SUMMARY:

Columbia Water & Light (CWL) conducted a test burn of pelletized miscanthus based solid fuel, supplied by MFA Oil Biomass, at its Municipal Power Plant in October 2012. Included with this memo is the report detailing the project and results from this test burn.

DISCUSSION:

Part of CWL's renewable energy supply strategy is co-firing biomass material with coal in CWL's solid fuel fired generation units at the Municipal Power Plant (MPP). Waste wood has been used at the MPP since April 2008. In an effort to determine what other bio-fuels might be available, CWL issued a Request for Proposals (RFP) in July 2011, to identify potential biomass fuels for testing purposes. CWL received six (6) proposals which could be divided into two groups. The first group, containing three proposals, was for wood derived fuels. As CWL had extensive experience with wood fuel, these proposals were not accepted. The second group, also containing three proposals, was for grasses, miscanthus, or other non-woody bio-mass. CWL decided to work with one of the respondents offering miscanthus based product - MFA Oil Biomass. CWL agreed to purchase up to 200 tons of test fuel at \$125 per ton.

The Environmental Protection Agency's (EPA's) issuance of the Cross State Air Pollution Rule in July 2011, delayed CWL's activities with regards to the RFP and any test burns, as that rule would have significantly reduced CWL's ability to self generate energy at the Municipal Power Plant. The rule was stayed by the courts at the very end of 2011.

CWL hired Shell Engineering to assist with the preparation of a test burn permit application with the Missouri Department of Natural Resources (MDNR), and to develop testing protocols. The permit application was filed on July 18, 2012, and MDNR issued a temporary permit on October 10, 2012.

MFA delivered 176.06 tons of miscanthus pellets between October 8 and 17, 2012. The pellets were cylindrical in shape with a diameter of 0.25" and a length of about 2" or less. The pellets were sampled and tested by CWL. The test burn was scheduled for the week of October 15th in conjunction with an EPA required annual Relative Accuracy Test Audit (RATA) at the MPP. CWL designed a test program to evaluate different fuel mixes containing wood-coal, coal only, and coal-miscanthus. Testing was to be done such that emissions factors could be established through stack testing, should CWL desire to apply to MDNR for a permit to combust the miscanthus fuel on a regular basis. The miscanthus-coal fuel mix entered MPP Boiler 7 on October 17th.

General Observations

Below are some observations made during the storage, handling, and combustion of the miscanthus fuel pellets:

1. The miscanthus pellets are very susceptible to moisture. While stored the fuel was covered with tarps. Areas in the storage pile that had water infiltration resulted in pellets that swelled, then disintegrated upon movement.
2. The miscanthus pellets became very dusty upon handling, which could lead to fugitive dust emission issues.

3. Coal was mixed with pellets in a five gallon bucket and left overnight to judge how the pellets might react while in a fuel mix pile. The pellets appeared to wick moisture out of the coal, and then swell and disintegrate.
4. The pellets were easily handled with the MPP's front end loaders.
5. The pellets mixed with the coal well, and traveled through the coal handling elevators and conveyors without issue.
6. By the time the pellets arrived at the stokers, they had broken in to small pieces that ignited at the outlet of the boiler producing large fireballs at the stoker outlets. MPP staff was concerned that the proximity of these fireballs to the stoker outlet could cause a fire further up the fuel train, therefore the test was discontinued after about two hours. The load on the boiler was reduced with slightly better results. The amount of miscanthus used in subsequent fuel mixes was reduced with better results. The stoker fireballs were reduced, but never eliminated.

CWL Recommendations

1. The fuel pellets should be larger so they are still of sufficient size by the time they reach the stoker and will enter into the furnace before combusting.
2. Storage and handling should be in-doors or otherwise protected from the weather.
3. If the pellets are used in their current form, a separate fuel handling system should be used to feed the pellets into the boiler fuel train at the coal scale level of the boiler.
4. Weatherproofing or other hardening of the pellets should be considered.
5. Future test burns should be done in two phases. The first should be a subjective test of the fuel handling characteristics, durability, and how the fuel combusts in boiler. Only upon a successful completion of the first phase, should stack testing and other objective tests be considered.

Project Cost

CWL's direct costs for the test burn was \$32,971.10 which includes \$21,882.50 paid to MFA Oil Biomass for the test fuel.

FISCAL IMPACT:

Not applicable.

VISION IMPACT:

<http://www.gocolumbiamo.com/Council/Meetings/visionimpact.php>

9 Vision Statement: Columbia residents and businesses conserve all the community's natural resources, work cooperatively to apply best planning practices, model energy efficiency, transition to renewable energy, and approach zero waste generation.

SUGGESTED COUNCIL ACTIONS:

None, Informational Only

FISCAL and VISION NOTES:					
City Fiscal Impact Enter all that apply		Program Impact		Mandates	
City's current net FY cost	\$0.00	New Program/ Agency?	No	Federal or State mandated?	No
Amount of funds already appropriated	\$0.00	Duplicates/Expands an existing program?	No	Vision Implementation impact	
Amount of budget amendment needed	\$0.00	Fiscal Impact on any local political subdivision?	No	Enter all that apply: Refer to Web site	
Estimated 2 year net costs:		Resources Required		Vision Impact?	Yes
One Time	\$0.00	Requires add'l FTE Personnel?	No	Primary Vision, Strategy and/or Goal Item #	9
Operating/ Ongoing	\$0.00	Requires add'l facilities?	No	Secondary Vision, Strategy and/or Goal Item #	
		Requires add'l capital equipment?	No	Fiscal year implementation Task #	



MFA Oil Biomass Miscanthus Test Burn Report

**Christian Johanningmeier, PE
Power Production Superintendent**

June 14, 2013

Summary

Columbia Water & Light (CWL) conducted a test burn of pelletized miscanthus based solid fuel, supplied by MFA Oil Biomass, at its Municipal Power Plant in October 2012.

Renewable Energy Ordinance

In November 2004, the voters of Columbia approved a renewable energy ordinance for the City's power supply portfolio. The ordinance mandates CWL supply increasing levels of energy from renewable sources per the schedule below.

Columbia Renewable Ordinance

Percent	Date
2%	12/31/2007
5%	12/31/2012
10%	12/31/2017
15%	12/31/2022

These energy supply requirements are subject to a 3% maximum impact on CWL's rate base.

Biomass Energy Production History

Part of CWL's renewable energy supply strategy is co-firing biomass material with coal in CWL's solid fuel fired generation units at the Municipal Power Plant (MPP). Co-firing began in April 2008 and continues to the present. Waste wood chips have been and continue to be the biomass material used. The chart below shows the results of biomass firing with respect to CWL's total system energy.

Biomass (Waste Wood) Production History

Year	System MWH	Waste Wood MWH	Percent
2008	1,146,543	3,902	0.3%
2009	1,105,255	5,171	0.5%
2010	1,185,352	7,432	0.6%
2011	1,173,851	11,818	1.0%
2012	1,180,154	5,964	0.5%

Production in 2012 was down primarily due to a comprehensive condition assessment done in the spring and summer that required the solid fuel units to be out of service.

Bio-Fuels Request for Proposal

In an effort to determine what other bio-fuels might be available, CWL issued a Request for Proposals (FRP) on July 5, 2011, see Appendix A. The purpose of the RFP was to identify potential biomass fuels for testing purposes. On August 12, 2011, CWL received six proposals which could be divided into two groups. The first group, containing three proposals, was for

wood derived fuels. As CWL had extensive experience with wood fuel, these proposals were not accepted. The second group, also containing three proposals, was for grasses, miscanthus, or other non-woody bio-mass. CWL decided to work with one of the respondents offering miscanthus based product – MFA Oil Biomass. See Appendix B for MFA Oil Biomass’s proposal. MFA Oil Biomass included test information for the proposed fuel which was dated March 25, 2011, and addressed to the University of Missouri.

The Environmental Protection Agency’s (EPA’s) issuance of the Cross State Air Pollution Rule in July 2011, delayed CWL’s activities with regards to the RFP and any test burns, as that rule would have significantly reduced CWL’s ability to self generate energy at the Municipal Power Plant. The rule was stayed by the courts at the very end of 2011.

On April 9, 2012, a purchase order was issued by CWL to MFA Oil Biomass for 200 tons of miscanthus fuel at a cost of \$125.00 per ton.

Key People

The key people involved in the planning and execution of the project were:

Columbia Water & Light

Christian Johanningmeier, PE, Power Production Superintendent

Mike Willingham, Assistant Power Production Superintendent

Steve Lewandowski, Assistant Power production Superintendent

MFA Oil Biomass

Jared Wilmes, Biofuels Coordinator

Jared Embree, Mechanical Engineer – Market Development

Shell Engineering

Sandra Cupp, PE, Engineer

Karen Curtit, PE, Engineer

Purpose of Proposed Test-Burn

The purpose of the test-burn was to determine if potential bio-mass fuels, other than wood, could be used in CWL’s solid fuel boilers when mixed with coal, and to analyze the following characteristics: fuel handling requirements or limitations, storage requirements, transportation requirements, heat value and other key fuel characteristics, and effects on boiler performance and emissions.

MDNR Air Permit

CWL hired Shell Engineering to prepare the necessary application with the Missouri Department of Natural Resources for permission to conduct the test burn. The application was filed on July 18, 2012, and a permit was issued by MDNR on October 10, 2012. See Appendix C for the application and Appendix D for the resulting permit and test plan.

Delivery and Storage of Fuel

MFA Oil Biomass delivered the pelletized miscanthus fuel product to the MPP per the table below. The fuel was delivered by truck and dumped into the west biomass fuel storage bunker at the MPP. The bunker has a concrete floor, a concrete wall on the east, a brick wall on the north, and a segmented concrete block wall on the west. Large tarps were procured by CWL and used to cover the fuel while in the bunkers. As delivered, the pellets were cylindrical in shape with a diameter of 0.25" and lengths of about 2" or less.

MFA Oil Biomass Fuel Deliveries

Date	Time	Tons
10/8/12	7:54	26.04
10/8/12	8:11	24.82
10/15/12	6:34	25.01
10/15/12	6:37	24.95
10/16/12	8:46	25.53
10/16/12	10:47	25.05
10/17/12	7:02	23.66
Total		175.06

Samples of the miscanthus pellets were collected and sent to Standard Labs for analysis. See Appendix E for the fuel analysis reports. The miscanthus pellets were found to have an as-delivered heat content of 7349 Btu per pound and a sulfur content of less than 0.01%.

Test Schedule

The test burn was scheduled to be done in conjunction with the Municipal Power Plant's annual Relative Accuracy Test Audit (RATA) which is done to certify the Plant's Continuous Emissions Monitoring System (CEMS). Testing was scheduled for the week of October 15, 2012.

Test Plan

The test plan developed by CWL was to burn various blends of fuels during the testing week, with the base fuel mix being used for the RATA test, a reference fuel mix consisting of a blend of Oklahoma and Illinois coals, and then two different mixes of coal and miscanthus pellets. The first miscanthus blend was designed to be similar to the base fuel mix consisting of coal and wood typically used at the MPP on a heat content basis. The second miscanthus blend was designed to double the content of the miscanthus, on a volume basis, when compared to the first miscanthus blend.

CWL desired to compare any data collected while burning the two miscanthus blends with the coal only reference fuel. Fuel analyses reports for the coals used are in Appendix F.

Stack Testing

CWL's stack testing contractor during the RATA and the miscanthus test burn was:

Rachel M. Chleborowicz
Environmental Chemist/Project Manager
RMC Environmental, Inc.
PO Box 1008
Elgin, IL 60121-1008
815-378-6150
rmceinc@aol.com

Stack gas parameters that were to be tested are indicated below:

Combustion Gas Analysis

Parameter	Stack Test	CEMS
O2	x	
CO2	x	x
NOx	x	x
SO2	x	x
CO	x	
Hg	x	
HCl	x	
PM	x	

MPP Unit Characteristics

The test burn was conducted in the MPP's Boiler #7 which was producing steam for the MPP's Turbine #7, which has an electrical generating capacity of 22 MW. Fuel is delivered to the boiler with a Hoffman spreader type stoker with traveling grate. The boiler characteristics are below:

Boiler #7 Characteristics

Make	Erie
Year	1965
Steam Capacity (KPH)	240
Steam Temp. (F)	900
Steam Pressure (psi)	875

Fuel Handling

Solid fuel at the MPP consists of coal and waste wood chips. Both fuels are stored outdoors, but in separate locations for each fuel. MPP personnel mix batches of fuel daily using a front end loader to obtain fuel from each storage location and then mix the fuel to a predetermined recipe on a volume basis. Once the fuel is mixed, it is dumped into a hopper, which is connected to a bucket elevator via a conveyor belt. The bucket elevator conveys the fuel to the roof of the MPP,

where it is dumped into a screw conveyor. The screw conveyor travels over the entry points to fuel bunkers that are located in the MPP. Each of the MPP's two solid fuel boilers has two bunkers of about 200 tons capacity each, which allows for 1.5 to 2 days of supply at moderate boiler loads. The bunkers feed into non-segregating chutes which supply the Hoffman stokers.

Fuel Mixes

As CWL uses a volume based method to produce fuel mixes, MPP personnel made fuel density measurements of fuels to be used during the test. Material was loaded into dump trucks, using the loaders that mix the fuel, and the dump trucks were weighed. Three samples of each fuel were measured. The results are shown in Appendix G.

Given test reports for the coal and wood, and the representative test supplied by MFA Oil Biomass for the miscanthus, four fuel mixes were designed. The Base Mix is the fuel mix regularly used at the MPP and was the fuel used during the RATA test. The Reference Mix was a coal only mix of two types of coal. Two Miscanthus Mixes were designed, the first to closely represent the wood in the Base Mix and the other to double the amount of miscanthus on a volume basis. See Appendix H for fuel mix details.

Testing Activities

Testing was done during the week of October 15, 2012 as follows below:

Monday, October 15

RATA test was completed using the Base fuel mix and a load level of 17 MW. The Reference fuel mix was loaded in the bunkers so as to arrive at the boiler the next day.

Tuesday, October 16

After some delay in waiting for the Reference fuel mix to arrive at the boiler, stack testing was performed at a load level of 21 MW. Miscanthus Mix #1 was produced and loaded into the bunkers so as to arrive at the boiler the next day.

Wednesday, October 17

The Miscanthus Mix #1 arrived at boiler at moderate boiler loads. Loads were increased and after about two hours, the stack test was abandoned on account of miscanthus fuel combusting too close to the stoker outlets. Load was reduced with slightly better results.

Rest of Week

Fuel mixes containing lesser amounts of miscanthus pellets were produced and fed into the boiler at a load of about 10 MW with slightly better results.

In order to produce valid stack testing parameters for possible future use, load test levels were set to be at a minimum of 95% of electrical capacity.

Test Data

Data was collected on the MPP's Continuous Emissions Monitoring System (CEMS), and is included in Appendix I. A summary of the CEMS data is shown below.

CEMS Summary

Test	Date	NOx #/mmBtu	Load Kph	Load MW	SO2 #/mmBtu	CO2 %
RATA - Base Fuel	15-Oct	0.465	157.6	17.5	2.410	8.3
Reference Fuel	16-Oct	0.522	189.3	21.2	2.692	8.6
Miscanthus #1	17-Oct	0.514	190.5	21.6	2.283	9.0

Data from the RATA test showing NOx and SO2 results from combusting the Base fuel mix are shown in Appendix J.

As the stack test was abandoned before the minimum required time had elapsed for the first miscanthus fuel mix, no stack test data is available.

Ash

Samples of bottom and fly ash were taken during the times when the reference fuel was combusted and the miscanthus fuel was combusted. The samples were sent to Standard Labs for analysis. See Appendix K for the test results.

Test Project Cost

CWL's direct costs for the MFA Oil Biomass test burn project was \$32,971.10, as detailed in the table below:

Test Burn Expenses

Item	Vendor	Cost
Miscanthus Pellets	MFA Oil Biomass	\$21,882.50
Engineering	Shell Engineering	\$ 6,956.30
Permit Fee	MDNR	\$ 100.00
Fuel Testing	Standard Labs	\$ 3,726.34
Stack Testing	RMC Environmental	\$ -
Tarps	Miscellaneous	\$ 305.96
Total		\$32,971.10

Project Photos

Several photos were taken during the test and are shown in Appendix L.

General Observations

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CWL Recommendations

1. The fuel pellets should be larger so that they are still of sufficient size by the time they reach the stoker that they will enter into the furnace before combusting.
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3. If the pellets are used in their current form, a separate fuel handling system should be used to feed the pellets into the boiler fuel train at about the coal scale level of the boiler.
4. Weatherproofing or other hardening of the pellets should be considered.
5. Future test burns should be done in two phases. The first should be subjective test of the fuel handling characteristics, durability, and how the fuel combusts in boiler. Only upon a successful completion of the first phase, should stack testing and other objective tests be considered.

Appendices

- A Request for Proposal 82/2011 – “Bio-Mass Fuel for Municipal Power Plant”
- B MFA Oil Biomass proposal with fuel analysis
- C MDNR permit application
- D MDNR permit and test plan
- E Miscanthus fuel pellet analysis – Standard Labs
- F Coal Fuel Analysis
 - F-1 – Wood
 - F-2 – Illinois coal
 - F-3 – Oklahoma coal
- G Fuel Density Measurements
- H Fuel Mixes
- I CEMS Data
- J RATA Data
- K Ash Analysis
- L Project Photos