




CITY OF COLUMBIA, MISSOURI

WATER AND LIGHT DEPARTMENT
COLUMBIA TERMINAL RAILROAD

MEMORANDUM

TO: Water and Light Advisory Board

FROM: Tad A. Johnsen, Director of Water & Light 

Date: August 22, 2013

RE: Biomass Test Burn

As part of its renewable energy program, Water & Light (CWL) has been burning wood at the Municipal Power Plant (MPP) since 2008 and has continuously explored the possible use of other biomass fuels for electrical power generation. In October 2012, CWL conducted a test burn of miscanthus derived fuel in conjunction with MFA Oil Biomass, LLC. The results of that test burn have been previously reported.

In 2012 CWL was awarded an American Public Power Association (APPA) Demonstration of Energy-Efficient Developments (DEED) grant to conduct research and develop a specification for an engineered biomass fuel product that could be used at the MPP and similar publicly owned facilities. On August 14, 2013 Water and Light staff, Missouri Corn Growers Association and MoCorn's sub-contractors completed a webinar outlining the development and elements of a trial burn plan, reviewing the findings of various biomass trial burns as well as testing analysis of new products (Engineered biomass – a collaborative effort between Missouri Corn Growers Association and Enginuity Worldwide) for future trial burn. The webinar is available to APPA/DEED members on the APPA website. This grant has been successfully completed on time, meeting all requirements outlined in the last scope of service.

Using the specifications developed, CWL solicited bids for the fuel to conduct a test burn. As CWL has already obtained a temporary permit from the Missouri Department of Natural Resources (MDNR), the quantity of fuel requested mirrors that allowed in the permit. On July 30, 2013, CWL received on bid from Enginuity Worldwide, LLC for 700 tons of fuel at a price of \$500 per ton, with a delivery time of 120 days after receipt of order. Total cost of the fuel will be \$350,000. The fuel will be derived from corn stover and/or a mixture of corn stover and grass. As reference, CWL paid \$125 per ton for the miscanthus derived fuel used during the October 2012 test burn.

When including the cost of stack testing, fuels testing, engineering monitoring and analysis, furnace monitoring and measurement, and incidentals, the total expected cost of a test burn is around \$375,000.

Phase II of the project is to complete a trial burn of the densified engineered biomass. To help offset some of the costs of the test burn, CWL and Missouri Corn Growers Association submitted a grant application to APPA DEED for Phase II. This grant application was submitted by the August 15, 2013 due date. The joint application is requesting \$125,000, which is the maximum available. The grant will assist with buying down the cost of the engineered fuel, covering costs of engineering assessments and \$25,000 for research.

The grant objectives are to take biomass energy to the next generation and make its use economically feasible to be co-fired in existing coal-fired plants. There are multiple raw feedstocks planned for the study which include: corn stover, energy crops and native grass crops densified into the engineered product. This demonstration project addresses previous issues identified with biomass co-firing and will further study the economic, social and environmental impacts of all facets of the project, not only for Columbia but selected regions of the U.S.

The project will demonstrate an integrated approach for sustainable fuel supply for existing power plants and all necessary analysis and verification. If the grant is approved as submitted, CWL's net cost of the test burn would be reduced to \$250,000. The APPA DEED grant recipients are scheduled to be notified in September.



TO: Columbia Water & Light Advisory Board

FROM: Nancy Heimann, Enginuity Worldwide LLC

RE: Engineered Biomass Solid Fuel (eCARB™)

DATE: August 28, 2013

Thank you for the opportunity to provide supplemental information. A proposed engineered biomass solid fuel test burn purchase order approval is on the agenda of the Water & Light Advisory Board (CWL) meeting for September 4, 2013. The eCARB™ fuel from Enginuity Worldwide LLC for a test burn is an innovative biomass fuel that is being developed to address the energy supply chain challenges of logistics, durability, and economic sustainability for biopower production.

Building a Sustainable Energy Chain *Working with all non-woody stakeholders*



The eCARB™ process (**e**nvironmentally **C**ontinuous **A**nnually **R**enewable **B**iomass) is built upon:

- Accessing multiple streams of annually renewable and locally grown biomass.
 - Applying patent pending technology to achieve a cost-effective, durable, transportable, conveyable product.
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- Partnering with stakeholders in the biomass value chain to build fuel manufacturing facilities.
 - Manufacturing solid fuel products that will meet the needs of local and regional power production facilities to generate Missouri home-grown power while promoting both market options and energy independence.
 - Utilizing legacy coal-fired power plants by providing a coal replacement or augmentation solution.

A recent newspaper article describing CWL's experience with of a previous test burn *with non-engineered* solid biomass fuels, points to the need for a thoughtful and technically sound approach to biomass fuel. Enginuity Worldwide (EWW) has been collaborating with CWL over the past two years, working to develop a final engineered solid fuel that will address the challenges identified in the Fall 2012 trial, the result is eCARB™ engineered fuel.

As with many product development challenges, the under-performance or deficiencies of previous work can be highly informative in arriving at long-lasting solutions. In the case of engineered fuel, eCARB, we specifically have addressed the challenges in providing annually renewable biomass fuel for the CWL power plant including, but not limited to, Durability, Transportability, Portability, Distribution and Weatherability.

It is believed that the problems and challenges were caused by densification methods and processes, rather than the raw biomass material itself. All evidence suggests that miscanthus is a good and viable fuel that holds great promise, if the actual product is engineered to perform as in the case of eCARB™ fuel. Also, engineering studies conducted by CWL suggest that the power plant is an excellent candidate power plant for co-firing biomass to achieve base-load annually renewable biopower.

If the miscanthus had been processed in a manner that meets the recently adopted CWL engineering material specification, it could have been expected that the trial would have avoided the problems described in the Test Burn report. It is a credit to CWL that specifications were adopted, the very same specifications that EWW believes it can meet or exceed with its eCARB™ engineered biofuel.

Several specific failure modes for handling the biomass pellets were observed in the pellet trial burn of October 2012, which EWW has specifically and proactively addressed, including:

1. **Pellet Durability** – Pellet durability is a standard measurement of biomass fuel, and is typically measured by methods published in Section 5 of American Society of Agricultural and Biological Engineers standard ASABE S269.4. The lack of durability of miscanthus pellets was identified as a primary source of failure observed with disintegration in handling, storage, and movement. eCARB™ engineered fuels are specified to be >97% durable.
2. **Material Distribution in the Boiler** – Based on the observations of the power plant personnel during the test, the October 2012 material did not distribute evenly in the boiler. In fact, the trial was terminated because of observations that the pellets became “fireballs” at the entrance to the boiler. The eCARB™ fuel has been designed to be the sized and shaped to work in concert symbiotically with the fuel with which it is being burned, in the case of CWL that is coal. In the case of eCARB™ materials, CWL plant engineers required that on-site material flow tests be accomplished prior to any consideration of a test burn. One such dynamic flow test was accomplished on engineered biomass fuel (50:50 engineered solid fuel: coal) from EWW and the size, shape, and initial durability of the eCARB™ solid fuel were tested in a “coal chute” demonstration. The objective of the test was to show how effective the current “flipper” system of distributing biomass chunks would be, as compared to the current solid fuel of coal. The following samples were trialed for material flow in March of 2012:



Figure 1: Samples of eCARB™ biomass fuel using mixed biomass (left) and corn stover (right).

The following image is looking through a “man-door” on the upper wall of the boiler, looking down onto the boiler floor. The black objects on the floor are coal chunks that were sent through the supply feeder first. The brown objects are biomass solid fuel that was sent through the supply feeder. The distribution of brown and black objects are fairly uniform across the area, indicating the size, geometry, and durability of the trialed biomass fuel would be adequate to be used as a cofire fuel with coal.



Figure 2: Placement of eCARB™ biomass fuel in CWL MPP Solid Stoker Boiler

The eCARB™ engineered biomass fuel was found to be free flowing through the coal chute apparatus, and a “flipper” air valve system was used to distribute the solid fuel onto the boiler floor. No signs of bridging or lodging were observed, thereby indicating a successful test.

In follow-on testing in May of 2013, a mix of coal:biomass 50:50 mix was directed down the feed chute similar to the test noted in the previous paragraphs. This follow-on test was conducted with the spacing gaps set at the minimum settings on the Firite Spreader Stoker. This was required to determine if the size proposed by EWW was effective at minimum setting on the CWL MPP plant.



Figure 3: Follow-Up Material Flow Testing for “Minimum” Settings on Firite Spreader Stoker. Shown on left before testing, and on right as flowing through the minimum clearance.

3. **Moisture Up-take During Storage** – The test burn of October 2012 indicated a problem with stability, and tolerance to moisture of the miscanthus pellets during storage. Up-take of water from comingled coal chunks was observed to cause catastrophic failure of the pellet form, and caused swelling and disintegration of the pellet. A repeat of the test in the EWW lab confirmed the problem with raw biomass compaction materials.

EWW has developed a weatherable form of biomass engineered fuel that was specifically developed to address the issues of moisture tolerance. Laboratory tests were conducted by EWW based on published methods to recreate the observed failure mode, and to compare the performance of the eCARB™ weatherable fuel. The testing method is based on data from public reports of other biomass tests, and involves immersing the subject solid fuel in a container of water for a test period. Observations of weight gain, and shape integrity may be taken at any interval, with some industry papers indicating 30 minute intervals to be appropriate. A 2 hour immersion time was chosen for this initial test. The 2 hour data replicated the failure of miscanthus pellets that was observed in the CWL trial burn. The eCARB™ engineered solid fuel did not lose any shape integrity during a 2-hour immersion test. Additional field / lab

coordinating testing may be completed to arrive at the most appropriate immersion interval to reliably predict behavior of the material in a particular storage scenario.



Figure 4: Left: Oak pellets: Moisture Gain (2 hours) 200%. Complete degradation of shape form.
Right: Grass Pellets: Moisture Gain (2 hours) 200%. Complete degradation of shape form.

Coal samples were also tested to determine an appropriate benchmark for water up-take.



Figure 2: Left: Illinois Coal: Moisture Gain (2 hours) 10%. No loss of shape form.
Right: Oklahoma Coal: Moisture Gain (2 hours) 16%. No loss of shape form.

The weatherable eCARB™ fuel had moisture gain of < 0.5% in 2 minutes, and 8% in 2 hours with no loss of shape integrity, as shown in Figure 3. It is expected that eCARB™ fuel will not experience the same failures of moisture degradation that was experienced with the miscanthus pellets.



Figure 3: Weatherable eCARB™ Fuel: Moisture Gain (2 hours) 8%

SEPTEMBER 4, 2013 ACTION ITEM- APPROVAL OF A PURCHASE ORDER

The proposal under consideration is a test burn purchase order for purchase of Missouri-produced biomass solid fuel product based on EWW's engineered approach to biofuel. Based on the laboratory testing to date, it is not anticipated that EWW will experience any of same handling or physical stability issues that were observed in the Fall 2012 test burn of miscanthus pellets. EWW requests the approval of this test burn quantity purchase order as soon as possible.

FUTURE OPPORTUNITIES – FUEL PURCHASE AGREEMENT

Upon completion of the test burn protocol, it is Enginuity's request that the City and CWL approve and sign a fuel delivery contract with Enginuity Worldwide (and its designated licensees) to develop and deliver engineered biomass solid fuel in quantities of a minimum of 10,000 tons per year at a price that is in concert with the City's renewable fuels ordinance.

The benefits to the City of Columbia Water & Light from this initiative will be:

- **Sustainable & Environmentally Friendly NEW Fuel Supply.** eCARB™ biomass fuel enables a "base load," home-grown annually renewable power source to add to the current woody biomass, solar, wind, and methane power portfolio in pursuit of compliance with the City's renewable power ordinance while taking advantage of market fluctuations and promoting energy independence.
- **Lowering emissions.** Biomass has been shown in other co-firing initiatives to lower emissions, including CO₂ and NO_x emissions, and give potential longer life to coal-fired facilities.
- **Reliability, Price Resilience, Diversity of Supply.** By accessing multiple sources of raw biomass and engineering the mix to meet technical and operational requirements of the user, the fuel supply is more reliable, price resilient and requires less capital to harvest. Rather than one source of raw biomass, the supply of which may be driven up or down due to seasonal,

regulatory or economic factors, the diversity of supply sources allows for more flexibility of biomass fuel make-up.

- **Minimal Retrofitting.** The eCARB™ biomass solid fuel proposed is being designed to be in a solid fuel form that is usable in the power plant with a minimum of process modifications. According to CWL engineers, any retrofitting of the plant is expected to be limited to previously planned and budgeted biomass storage areas.
- **Coal Supplement.** Establishing a fuel source for coal supplement or augmentation with biomass is consistent with numerous global and national macroeconomic and regulatory trends. This contract has the potential to serve as a cornerstone of the supply sources development, on which to build further biomass generation capacity, if the City chooses to do so.
- **Promoting Economic Development.** Furthering the marketability of Columbia and, therefore, economic development with multi-national corporations that have carbon footprint goals, and sensitivity and have voiced desire for locally produced renewable base load energy.
- **Creating a New and Sustainable Missouri Agriculture Market.** Contributing to regional and state-wide economic growth without competing with Missouri's food crop production or wood products industry.

Enginuity is delighted that the City of Columbia would be an early adopter of this process technology and be among the first to pioneer home-grown energy of annually renewable Missouri biomass. Energy independence is an initiative that has far-reaching benefit to the Columbia region and the State. By providing a commercial marketplace for home-grown locally produced fuels, the City is affecting economic and rural development that has far-reaching implication. It is not an overstatement to suggest that Columbia could be a catalyst for a rural economic transformation and transitioning to a new home-grown economy/commodity. A letter detailing the estimated impact of the solid fuel production is attached, as well as an exhibit showing potential eCARB™ "energy shed" areas that are being evaluated for supplying the needs of a future Columbia biomass fuel contract.

This test burn fuel purchase order is a first step to achieving new sources of non-woody, annually renewable, base load biopower for Columbia. With execution of the final fuel purchase order, Enginuity will proceed rapidly to work with other stakeholders in the biomass value chain to finalize supply and licensing agreement for the execution of the collaborative plans being developed with Columbia. Copies of letters from a few of the diverse stakeholders are attached for your review.

If you have any questions please contact me at 573-682-0042 or at nancy@enginuityww.com.

Thank you.



Enginuity Worldwide LLC is a Boone County, woman-owned, small business, with significant experience in engineered product development where the targeted end-product is custom-designed to meet the cost and performance requirements of the end use. Our mission is to provide elegant and cost efficient proprietary solutions to, seemingly, intractable engineering challenges, particularly in the area of materials development. We have worked with national and international enterprises on projects ranging from corrosion protection for power transmission hardware, metal surface treatments for high-end metals, and nano-cleaning techniques for surgical instruments in VA hospitals. In each case, proprietary technology was applied to overcome existing challenges, not dissimilar from the challenge of using raw bulk biomass in existing power plants.

Please contact Nancy Heimann at nancy@enginuityww.com or 573-682-0042 for further information.