Ecoremedy™ – The Bolivar Report

Project Location:

Bolivar feed mill
Fairmount, GA (Cumming Complex)

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Tyson - Bolivar Feed Mill

Background and General Discussion:

Tyson Foods owns and operates a feed mill in Funkhouser (Bolivar), Georgia; a small town just South of Fairmount in Bartow county in northwest Georgia. The feed mill currently consumes natural gas to produce low pressure steam (110 psig) for use in making feed pellets.

The mill operates twenty four (24) hours per day for five (5) days per week to produce 8,500 tons per week of poultry feed. It consumes an average of 5,581 MMBtu/month of natural gas and 562,425 kWh/month of electricity.

rem Engineering designed, constructed, installed, commissioned and operated the first commercial scale, ***Ecoremedy***™ solid fuel gasifier at Tyson's Bolivar feed mill for demonstration and testing of poultry litter and other industry by-products as boiler fuel. The purpose of the demonstration project was to show the successful conversion of poultry litter to energy using the ***Ecoremedy***™ gasifier to replace traditional fossil fuels such as natural gas and oil to generate steam for industrial use (process steam and electrical generation). In addition, the demonstration sought to establish a market price for the generation of the nutrient rich ash product to the agricultural industry for use as a fertilizer and animal feed supplement. rem installed the ***Ecoremedy***™ gasifier during February and March of 2008 and the unit operated until the end of January 2009.

Please see the attached Term Sheet between Tyson and rem Engineering for a more detailed outline of each company's role and contributions to the project.

The gasifier used in the demonstration was constructed during the winter of 2007/08 for Illinois State University (ISU) to be used for research and development as a Mobile Thermal Destruction Unit (MTDU). ISU, in partnership with the Propane Education and Research Council (PERC) plans to use the ***Ecoremedy***™ gasifier to evaluate ways to responsibly dispose

of routine poultry mortalities and, ultimately, other animal mortalities (e.g., potentially infected materials and wastes not accepted for rendering) and related wastes in an expedient manner that minimizes risks to worker health and safety, public health, and other environmental health (e.g., air, water, soil and food quality protection).

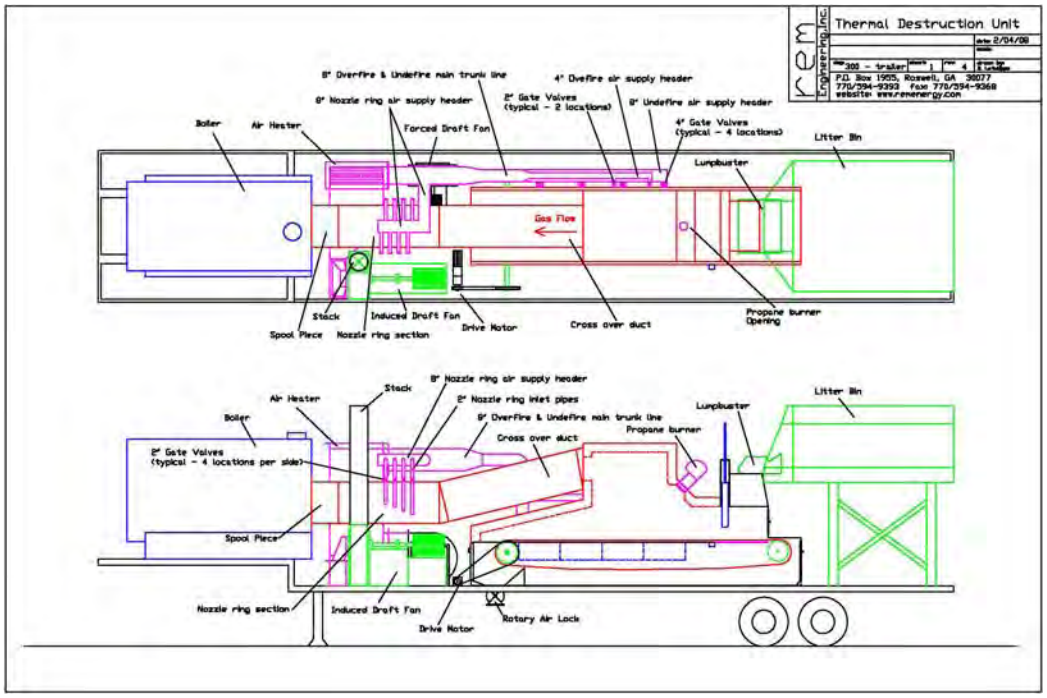
rem Engineering negotiated possession of the ***Ecoremedy***™ gasifier with ISU for the year long demonstration period with Tyson. Following completing operations at the feed mill in January of 2009, the ***Ecoremedy***™ gasifier was decommissioned and delivered to ISU. ISU is currently in the process of setting up the gasifier for testing as a MTDU on mortality.

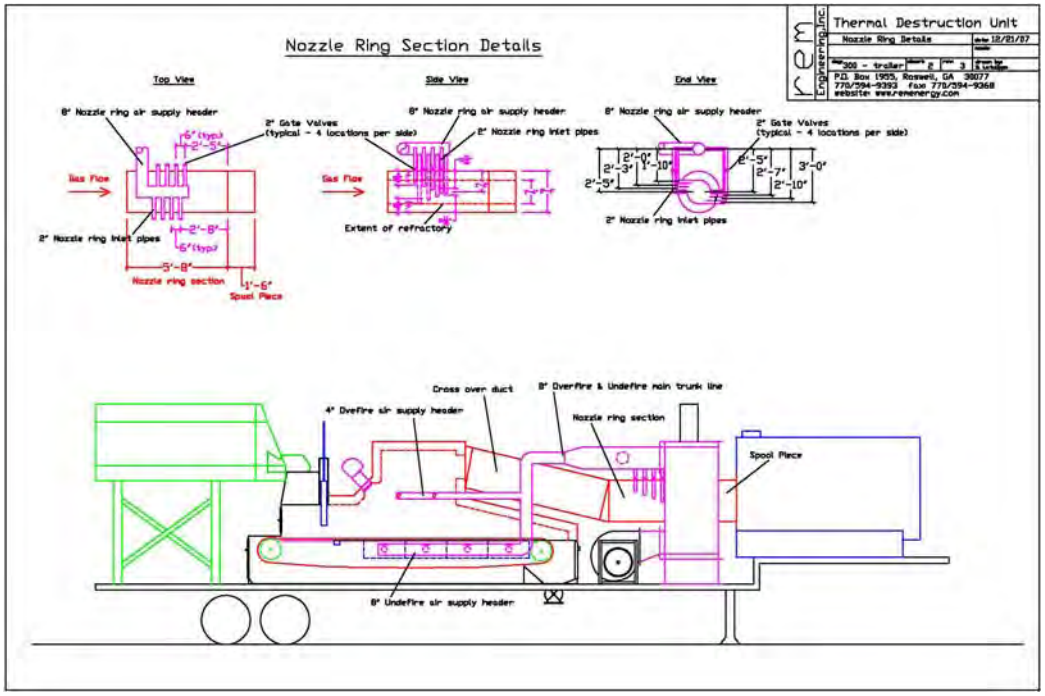
Description of *Ecoremedy*™ Gasifier:

The ***Ecoremedy***™ gasifier used in the demonstration (pictured on the right) was mounted on a 48 ft long, step-deck trailer. The trailer was a complete biomass fueled steam plant combining rem Engineering's ***Ecoremedy***™ technology with a modified Clever Brooks scotch marine boiler. The steam plant included an air-to-air heat exchanger important for gasification of high moisture material. Furthermore, the heat exchanger improved system efficiency by recovering the boiler stack heat.

A 2 MMBtu/hr, Gordon Piatt propane burner was mounted through the ignition arch of the gasifier. The angle of the ignition arch directed the propane flame onto the pile for use when mortality was conveyed through the gasifier. When operating on poultry litter as the fuel, the propane burner was used to pre-heat the gasifier and boiler as well as downstream equipment. The propane burner was not used during the gasification of litter or other refuse during the ***Ecoremedy***™ demonstration. A large refractory lined cross-over duct (16" I.D.) transferred the biogas from the gasifier to the boiler and incorporated the secondary burner or combustion zone of the system. The secondary burner consisted of a series of four (4) cascading 2" valves on both sides of the cross-over duct (combustion zone) preceding the entrance to the boiler. At this location, we introduced the balance of air required to combust the biogas.

A common control panel featuring PLC controls and housing all motor starters was mounted on the side of the metering bin supports. The touch screen control panel enabled the operator to start/stop all motors and vary the speed of both fans (force draft (FD) fan and induced draft (ID) fan) as well as the gasifier grate speed. An alarm screen identified the cause for fault and a red light illuminates to indicate a fault occurrence. See drawings below of trailer mounted steam plant.





An incoming power source of 480 volts is required to run the trailer mounted unit. All transformers required to run motors are provided in the control cabinet. The control cabinet with PLC controls is mounted on the side of the metering bin supports (shown circled in photo below at lower left – egg shell white).

Above: Photo of MTDU at 2008 International Poultry Expo in Atlanta, GA

The steam plant was remarkably simple to operate. Solid fuel (mortality, litter, etc.) was metered into the gasifier through a guillotine gate used to regulate the depth of the fuel bed. The gasifier fuel conveyor was controlled through the PLC control panel with a variable frequency drive (VFD). By changing conveyor speed and fuel bed depth, the operator was able to control the load on the unit. As fuel characteristics changed, the FD fan speed was changed to adjust gasification and combustion conditions within the system. The ID fan always maintained a negative pressure within the system equal to the set point inputted by the operator into the PLC controls.

Ash from the gasifier discharged through a rotary airlock located in the center of the trailer. This ash was conveyed away from the trailer when in operation. Further description of this ash removal system along with photographs are included in the following Physical Description of Plant section.

Physical Description of Plant:

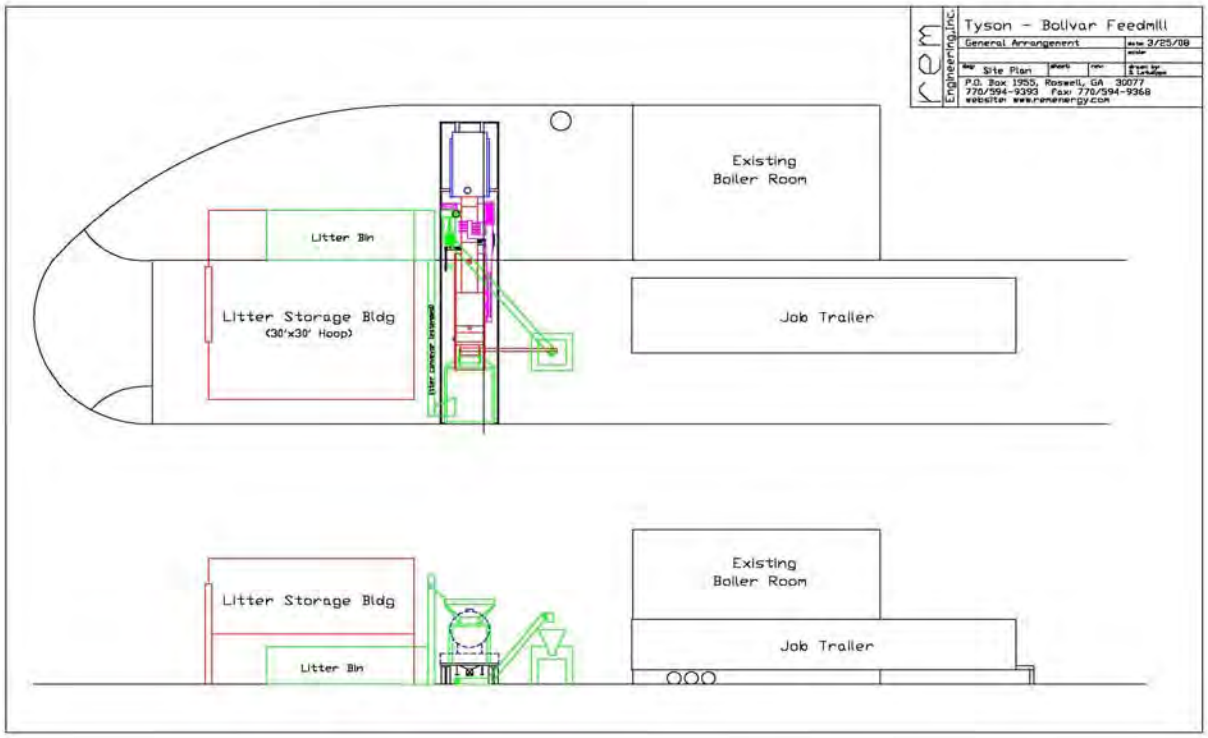
The ***Ecoremedy***™ gasifier installed and operated at the Tyson feed mill is the gasifier built for Illinois State University. The gasifier was mobile and mounted on a step deck trailer, 8 feet wide x 48 feet long and 13 feet tall. The litter building was a 30 foot wide x 30 foot long hoop building allowing for two full days of storage. The boiler was a Clever Brooks scotch marine boiler modified for use with our technology and high ash solid fuels. The modifications were designed to prevent fouling and to maintain heat transfer during extended operation with high flue gas precipitate. A complete control panel for the operation of the gasifier, boiler and material handling equipment was mounted on the trailer under the fuel hopper. Force draft and induced draft fans equipped with variable frequency drives (VFD) provided the necessary combustion air and negative pressure within the gasifier. Flue gas exiting the boiler was cleaned before venting to the environment. A combustion air heater and bag house served to cool and clean the exit gases respectively. Boiler make-up was treated in conventional water softeners. All plant components were conventional industrial grade equipment standard to industry.

rem supplied the feedmill with energy in the form of steam. The 130 BHP steam plant was located adjacent to the existing boiler house. Steam was delivered to the existing feed mill via a pipe bridge and interconnected into the mill's existing steam distribution system. The ***Ecoremedy***™ plant converted poultry litter from nearby Tyson grower's farms over the course of the demonstration. The litter was delivered to the plant site in covered trailers and unloaded into the litter storage bay. Odor control was managed by storing the litter in an enclosed building with combustion air required for the gasification process being drawn from the litter storage bay. A negative pressure within the building was maintained whenever the plant operated and all odors were combusted in the furnace section of the boiler. When not in operation, all litter bay vents and doors remained closed. This protocol proved effective and was approved by the Maryland Department of the Environment (MDE) in our air permit to construct a larger scale facility.

The 30 ft x 30 ft hoop litter building was located adjacent to the gasifier. Within the fuel bay was a litter metering bin (litter spreader) with a conveyor floor to automatically feed the ***Ecoremedy***™ gasification unit. The fuel exited the metering bin and was conveyed to the feed hopper of the gasification unit through the hoop building wall. The material was conveyed in an enclosed inclined drag chain conveyor to ensure cleanliness.

The ash from the ***Ecoremedy***™ gasifier was discharged through the airlock on the trailer into an enclosed inclined ash conveyor. This conveyor removed the ash away from the trailer and raised it to be discharged into the ash bagging station. The ash bagging station diverted the ash from the conveyor into one (1) ton super-sacks for ash handling and transport.

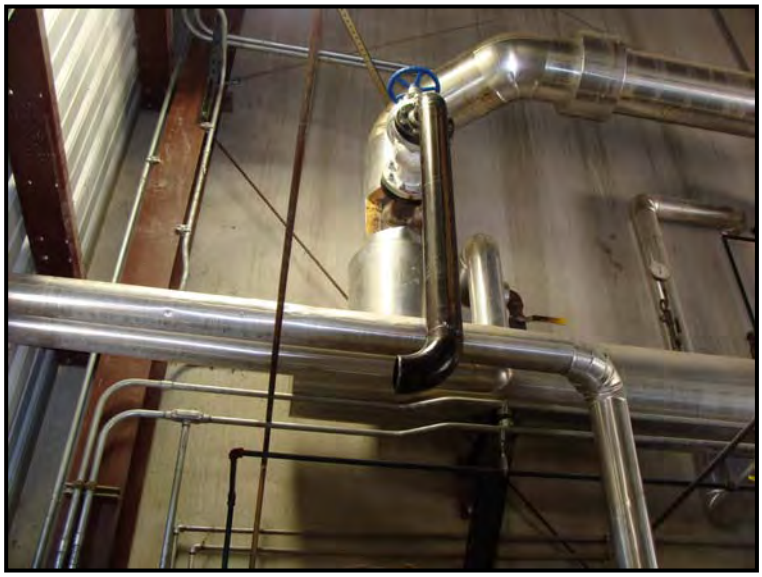
The ***Ecoremedy***™ plant layout drawing for the demonstration and photographs of the facility in operation are shown below.



The photo on the right is a picture of the entire site; the ***Ecoremedy***™ gasifier is in front of the litter storage hoop building. The job office is behind the Tyson truck in front of the existing boiler room. The baghouse is the blue box structure located behind the hoop building and in front of the silos. Steam from the gasification of wet chicken litter vents from the stack on the baghouse.

The photo below shows an operator after just removing a super-sack full of valuable nutrients.

The photo to the right shows the 110 psig steam line from the ***Ecoremedy***™ gasifier to Tyson's existing steam header in their boiler room. The ***Ecoremedy***™ technology is easily integrated into existing facilities.



Accomplishments and Lessons Learned:

The ***Ecoremedy***™ gasifier was located at Tyson's poultry feed mill in Funkhouser (Bolivar), GA. It was operated 24 hours per day, five days per week (Sunday night through Friday afternoon) from March 2008 until January 2009. During the 120 hour workweek, we generated an average of 1,400 lbs/hr of steam at 110 psig to the feed mill for use in the pelleting process.

As described previously, with poultry litter as the fuel, propane was used during start-up and shut-down every week to follow the operating hours of the feed mill. During a cold start-up, volatile gases are released in the gasifier. These tar laden gases condense on "cold" surfaces down stream of the gasifier. Boiler tubes and the air heater become fouled with tars before the system is placed into operation. By preheating the entire system with the 2 MMBtu/hr propane burner we avoided the tarring problem. Once the system was fully heated, the propane burner was turned off and the biomass gasification process was self sustaining.

Over the course of the demonstration, the following operations, accomplishments and results were obtained:

- Exceeded all design criteria pertaining to gasifier performance:

Design Point:	**Obtained:**
o feed rate = 6.5 MMBtu/hr	feed rate = 7.5 MMBtu/hr
o mass flow = 1,250 lbs/hr	mass flow = 1,453 lbs/hr
o fuel MC < 30% (x weight)	fuel MC > 64% (x weight)
o energy content = 5,000 Btu/lb	energy content = 3,627 Btu/lb

- Achieved and exceeded target temperature of 2,300 ºF
  - Measured temperatures at 2,500 ºF without propane.
  - We burned up six (6) thermocouples with a rating of +/- 2,500 ºF, therefore we project unmeasured temperatures were achieved that exceed 2,500 ºF.

- Once fully commissioned, the uptime of ***Ecoremedy***™ gasifier was exceptionally high, nearing 100%.

- Ease of operations was determined. One operator per shift successfully ran the ***Ecoremedy***™ steam plant.

- ***Ecoremedy***™ air control technology proven. Despite manual controls on the mobile plant AND variability of the fuel, few adjustments were necessary after gasifier steady state was achieved.

- Low Carbon Monoxide (CO) measurements
  Stack CO measurements were consistently less than 100 ppm. This is an indication that complete combustion of the bio-gas was achieved.

- Low stack O_2

  Stack O_2 is a measurement of the amount of excess air in combustion. Typical wood (solid fuel) biomass gasifier O_2 readings are between 5% and 7% which is consistent with biomass plants. The oxygen readings are another indicator of good combustion practice within the system. Lower stack O_2 readings between 2% and 3% provided improved emission results and lower gasifier temperatures. These lower temperatures resulted in ash with more available nutrients. Please see the emission section of this report for more information.

- Ash purity

  Ash quality is an indication of gasification performance. The ash from the ***Ecoremedy***™ gasifier is a very low carbon, fine, dusty particle. The material is extremely consistent indicating thorough and complete conversion of the energy. Eighty five (85) tons of high quality ash was generated during the pilot demonstration. We established an ash value of $250 - $325/ton FOB plant site through repeated sales to farmers as a natural fertilizer for row crops and certain grasses. Please see the attached ash nutrient analysis test reports and dioxin/furan testing reports on ash produced during operations.

- Other fuels:
  - Mortality – Five Hundred (500) pounds of poultry (chick) mortality were delivered to the site. Over the course of four (4) hours, the mortality was fed into the fuel feed bin and subsequently into the gasifier. The fuel mix was 25% mortality and 75% litter. No adverse effects to the combustion were observed. No emission testing was performed during this trial.

  - Routine mortality disposal was conducted throughout the demonstration. Conventional practice in Georgia is to compost the dead in the litter. We encountered partially decomposed bird carcasses on a daily basis.

  - Documents (disposal for Cumming complex) – The Cumming complex delivered several pick up loads of documents to be shredded and disposed of safely and in a confidential manner to avoid formal document disposal fees. The mix of litter and paper was more of a material handling issue than anything else. The paper needs to be shredded into small (2”-3” minus) pieces for thorough mixing. For the demonstration, the paper was not shredded small enough and separated out from the litter while being conveyed into the gasifier. Nevertheless, the gasifier successfully converted all paper refuse to usable steam.

  - Spilled/spoiled feed – The ***Ecoremedy***™ gasifier accepted the spilled and spoiled corn collected from the normal operation of the feed mill. Over the course of the demonstration, spilled feed collected from the feed mill and molded corn from silo clean-out was sent to the gasifier. This spilled and

spoiled feed was in the litter fuel during the emission testing and did not adversely affect performance.

During facility commissioning and the eleven (11) month operating period, problematic areas were identified and corrected. Problem areas included:

- Grate drive sprocket spacing
  After experiencing premature conveyor belt failure, rem contacted Cambridge International to review the application and belt selection. Cambridge was **NOT** the original supplier of the conveyor belt. Cambridge noted that the belt selection was correct but there were too few drive sprockets installed. The over spacing of the sprockets imposed stresses greater than conveyor belt specifications and resulted in accelerated fatigue of the belt. Future grate systems will used one drive sprocket per every two inches compared to the mobile unit which used one sprocket per every five inches. To further accommodate high load rates, the new belt system will incorporate longitudinal supports every eight inches whereas the mobile unit has no longitudinal reinforcement. rem has selected Cambridge International to fabricate the entire Ecoremedy™ grate system complete with drive assembly. **Cambridge International provides a one year warranty and performance guarantee on the Ecoremedy™ grate system.**

- Distance between the gasifier and combustion zone
  The distance between the gasifier and the combustion zone was too great. We added two new air ports along the length of the cross-over duct to facilitate staged combustion of the bio-gases. This modification enabled the operator to lower the temperature within the gasifier chamber while maintaining a strong flame in the secondary burner.

- Capacity of cross over duct combustion zone
  The volume of the combustion zone in the cross over duct was not adequate for complete combustion of the biogas generated in the gasifier at full load. As a result, smoke and odors were generated during incomplete combustion of the biogas. **This was resolved by reducing the load on the gasifier to match the capacity of the combustion zone and resulted in clean, odorless emissions.**

- Material handling/Litter fuel in-feed conveyor
  The inclined drag chain fuel feed conveyor was the major source of downtime during the demonstration. In an effort to keep costs down for the demonstration, Tyson provided this conveyor at no charge from a previous decommissioned project. The conveyor required modification and was extended by adding a 16' section. This extended the conveyor to the necessary height for the litter feed bin on the trailer. The size, weight (gauge) and type of chain for this conveyor was not adequate for this application or material. A larger motor and stronger gear box were needed to convey the wet litter to the gasifier.

The photos below help illustrate the successful operation of the *Ecoremedy*™ gasifier.

Photo #1: ***Ecoremedy***™ gasifier arriving on site in northwest GA

Photo #2: ***Ecoremedy***™ gasifier installed and operating

Photo #3: Cyclonic flame in burner ring as seen through the boiler

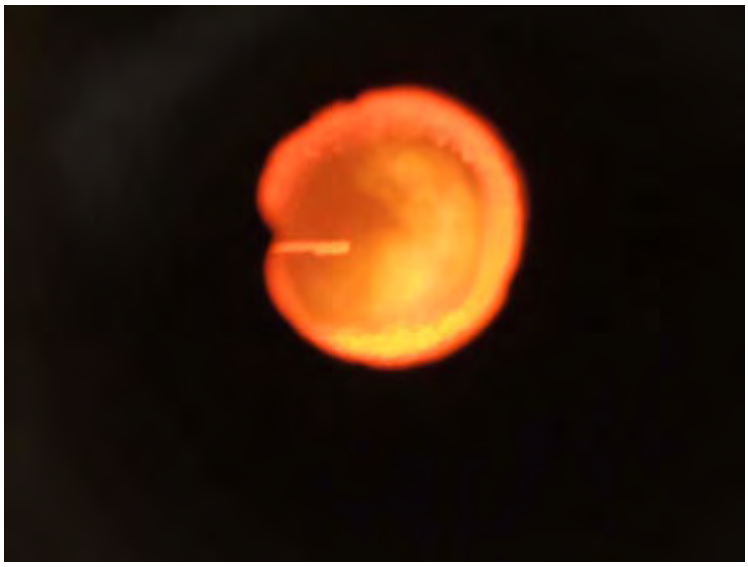


Photo #4: Yellow circle identifies the mach line during a steam blow

One year check-up:

The condition of the mobile Ecoremedy™ steam plant was evaluated during decommissioning from Tyson and preparing the unit for delivery to Illinois State University. For a unit that was installed outdoors without cover and operated through four (4) full seasons, the condition of the equipment was exceptional.

Gasifier – Excellent condition:

The only area of wear within the gasifier was one piece of refractory, about 10 pounds, which dislodged from an exposed corner joint in the chapel of the gasifier. Inspection revealed the area was improperly anchored. We installed three anchors and repaired the area with plastic refractory. We carefully inspected the gasifier and found no other areas of wear within the unit.

Biogas Transfer Duct – refractory was in excellent condition:

We experimented with different materials throughout the Ecoremedy™ system to determine the best method of insulation and to minimize the weight of the trailer mounted plant. The biogas transfer duct was insulated with high temperature board without refractory. This region condensed flue gas creating a protective clinker in the ductwork only. Refractory lined areas did not clinker. Future plants will utilize the same refractory blend used for the mobile unit.

Boiler – Excellent condition:

We manually cleaned and inspected the tubes every week for the duration of the demonstration. There was no degradation of the boiler tubes and heat transfer surfaces. Soot blowers are necessary to provide continuous cleaning of a light weight potassium chloride (KCl) precipitate that occurs. The bulk density of the precipitate is 11 lbs/ft^3.

Air Emissions:

Air testing performed by an independent EPA approved company confirmed ***Ecoremedy***™ meets federal permitting limits. Testing was conducted in general accordance with U. S. Environmental Protection Agency (USEPA) test methods. A summary of the test report is below. Please see attached for the complete final report.

Narrative:
rem Engineering is the inventor of ***Ecoremedy***™**,** a biomass gasification technology designed specifically for agricultural waste material including animal tissue (offal and mortalities), poultry litter, animal manure and process sludge. rem Engineering began operation of a pilot facility located at Tyson Foods' Bolivar feed mill in Fairmount, Georgia in March, 2008. Over the course of the next eleven months, the pilot plant operated 24 hours per day, 5 days per week.

The exclusive fuel source was poultry litter during the emission testing. ***Ecoremedy***™ converted over 500 tons of poultry litter (100% cake out) to 110 psig steam for process use in the feed mill during plant uptime. The pilot plant accounted for approximately 20% of Tyson's steam consumption. Eighty five (85) tons of high quality ash was generated during the pilot demonstration. ***Ecoremedy***™ ash was tested and found to be below the limits set by the European Union (EU) using the TEQ metric established by the World Health Organization (WHO) for measuring dioxin and furan levels in animal feed. ***Ecoremedy***™ ash is able to be used as an all natural fertilizer and feed nutrient supplement around the globe.

Advanced Industrial Resources, Inc. (*AIR*) conducted independent emission tests on September 24, 2008. All test procedures complied with Environmental Protection Agency (EPA) requirements for certified results. Contained herein are the summarized emission test results for the following compounds:

- Nitrogen Oxides (NO_X)
- Sulfur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Oxygen (O_2)
- Chloride (Cl)

Ecoremedy™ technology is designed to use the constituents in the poultry litter to self scrub critical pollutants. To test the gasifier performance, *uncontrolled* flue gas testing was conducted at the boiler exhaust stack prior to the baghouse or any emission control equipment.

The poultry litter gasified during the test contained the following concentrations (% by wet weight basis):

- 2.7% total Nitrogen
- 2.6% total Phosphorous – P_2O_5
- 2.7% total Potassium - K_2O
- 1.8% total Chlorine
- 64.2% free water – H_2O

The raw emissions data listed below were measured when the ***Ecoremedy***™ gasifier was operated at a boiler stack oxygen (O_2) level of 5.4% with a stack temperature of 485ºF. For permitting, flue gas emissions are corrected to and reported at a 7% O_2 concentration by volume. As tested, the limiting pollutant is NO_x.

Corrected to 7% O_2, an *Ecoremedy*™ gasification system sized at 3,543 boiler horsepower (BHP) or 122,250 lbs/hr of steam capacity meets Federal minor source criteria (< 100 TPY) for all of the identified criteria pollutants listed below.

The raw emission data for ***Ecoremedy***™ recorded at 5.4% O_2 for the following pollutants at are tabulated below:

Pollutant	Emission Rate (lbs/hr)	PPM	% Federal limits	BHP Allowed
NO_x	0.386	114.9	1.693	2,366
SO_2	0.210	44.9	0.921	4,349
CO	0.333	162.9	1.461	2,742
Cl	0.006	0.00145 (gr/dscf)	0.256	15,631

Once the official emission tests were performed, rem Engineering purchased a flue gas analyzer approved by the EPA for annual permit certification to continue our research and development and conduct ongoing emission testing,. The ECOM J2KN OCNXS analyzer enabled rem Engineering to fine tune the ***Ecoremedy***™ gasifier performance.

Subsequent testing revealed gasifier stack O_2 levels between 2.0% and 3.0% reduce the emission rates reported by AIR. Further emission testing conducted by rem Engineering using the ECOM analyzer suggests ***Ecoremedy***™ plants sized in excess of 135,000 lbs/hr of steam capacity will be permittable as minor source facilities (< 100 TPY).

An estimated 97% of all poultry manufacturing plants (feed mill, processing, rendering) fall within minor source permit limits for the ***Ecoremedy***™ technologies projected performance. Furthermore, most states require only a permit modification rather than a new source review for ***Ecoremedy***™ facilities as the ***Ecoremedy***™ plant replaces existing fossil fueled boilers.