Appendix B

Technical Performance: Ecoremedy® Gasifier Poultry Litter Furnace

A summary of preliminary technical performance findings funded by the Farm Manure-to-Energy Initiative

January 2016

Contents

1. The Technology

Installed on the Flintrock Farm in the summer of 2014, the Ecoremedy ® gasification system is a fixed feed rate system with a designed output of 0.8 -1.2 MBtu/hr. This system is designed to accept the poultry litter in the "as-is" condition. In theory, the system can use poultry litter with moisture levels up to 50%, although lower moisture content increases heat delivery.

The Ecoremedy gasifier is a chain-grate, air-blown gasification system in which fuel enters an oxygen-starved gasifier. Syngas generated from the gasification process enters a separate oxidation chamber where it is combusted. Heat gases from the combustion chamber then pass through a boiler used to heat water.

The Ecoremedy system consists of four primary components: 1) the gasifier; 2) the boiler; 3) the material handling system for fuel and ash; and 4) the hydronic heating system. The litter is loaded into a standard litter spreader modified with an electric motor to move the litter into the gasifier (figure 1). Prior to entering the gasifier (figures 2 and 3), the litter passes through a de-lumper, which breaks up the clumps in the litter (figure 1). After the de-lumper, the litter moves via a conveyor belt to a surge hopper on the gasifier, which also acts as an airlock.

The gasifier uses a chain grate to convey the litter through the gasification zone. The residence time is controlled by the speed of the conveyer belt, and the feed rate is controlled by a slide gate that adjusts the bed depth and the conveyor belt speed. The chain rides over perforated cast iron plates. Underfire air is blown through these holes and through the moving bed of litter. There are three separate underfire zones so the amount of air can be controlled independently (via manual controls) in each zone to fine tune the gasification to accommodate changes in the litter. Although the system is designed to operate at a constant feed rate, manure controls provide options for changing the feed rate if necessary.

Gate height and grate speed are independently adjusted to achieve the desired feed rate. These adjustments also allow for consideration of the litter bed depth and residence time. Proper adjustment of feed rate is critical for complete gasification of the fuel. For example, if bed depth is too high or the grate speed to fast, then gasification of the poultry litter could be incomplete, reducing the energy output and increasing the carbon and volume of the ash.

The litter that has been converted to ash falls into an ash bin at the end of the chain grate, where the ash is augered automatically outside of the gasifier, and into a dump hopper. Ash is stored in concrete walled structure to ensure complete cooling prior to bagging for off-farm transport.

The syngas created in the gasification zone flows into a separate chamber above the gasification chamber where secondary combustion air is blown in at different locations to completely oxidize the fuel. This two-stage system allows for complete control of the combustion process and complete oxidation of the fuel.

From the secondary combustion chamber, hot gases flow into a three-pass fire tube boiler (figure 2). This boiler is a standard off-the-shelf boiler (Superior Boil Works, Inc. Model #MS3-OB-270-W30) with the entrance modified to bolt to the gasifier. The flue gases leave the boiler and are pulled through the system by an exhaust fan. There are two cyclones in series that are designed to control particulate matter emissions. After the flue gases leave the cyclone they are vented to the atmosphere.

The hydronic heating system uses standard plumbing components to each of the four houses. Each house has three Landmeco heaters (model number 94-900), for a total of twelve heaters. Each heater has a thermostat to control the amount of heat the Landmeco will pull from the hot water. The gasifier output does not modulate according to the heat demand from the four houses, always running at 100% for a given feedrate. Any excess thermal energy not used in the houses is released to the atmosphere by a large radiator near the gasifier. A bypass valve, controlled by a thermostat near the boiler, activates the heat dump equipment if the incoming water temperature is above a certain threshold.

Figure 1. Litter starts in the litter spreader (white piece of machinery) that goes through a lump breaker (grey piece labeled “Danger”) and then is conveyed to a hopper above the gasifier (hopper not pictured).

Figure 2. The gasifier is the gray colored device and the boiler is the blue colored equipment at the top. The litter flows through the unit from left to right.

Figure 3. Flame from the combustion of the gasifier-generated syngas inside the combustion chamber.

2. The Farm

Along with contributions from Enginuity Energy LLC and Flintrock Farm, funding from the Farm Manure-to-Energy Initiative (from private foundations) and the Pennsylvania Natural Resources Conservation Service's Environmental Quality Incentives Program was used to install the Ecoremedy gasifier at Flintrock Farm in Lititz, Pennsylvania. Flintrock Farm produces organic broiler chickens in twelve poultry houses. At the start of the project, the farm produced conventionally-raised broilers. In January of 2014, the farm began producing organic broiler chickens for Coleman Natural. Birds are grown to 6.3 pounds over a fifty-day period.

The gasifier was installed to heat four poultry houses; two of the houses are 44 feet by 500 feet, and the other two houses are 54 feet by 600 feet (108,800 ft^2 total area). There are also an additional eight poultry houses, each 44 feet by 500 feet, located on a separate tract of land down the hill that are also part of this farm (but not part of the gasifier heat distribution system). In addition to poultry, the farm offers horse stabling and a riding arena. The farm also has forty acres planted in hay.

Depending on the farm's whole-house clean out schedule, the four houses heated by the gasifier produce between 750 to a little more than 1,000 tons of poultry litter per year, which is stored in a covered storage facility. Litter is "caked out" between every flock. Based on the farm's comprehensive nutrient management plan recommendations, between 2 and 3 tons of poultry litter (80 to 120 tons per year) are applied to the farm's hay acreage. Prior to installation of the gasifier, the remainder of the litter was exported off the farm, often for use in the mushroom industry. The gasifier uses 4.5 tons of poultry litter per day. If the system is operated for both heat and litter moisture control, the system would use all of the farm's exported poultry litter. An October 2015 poultry litter sample indicated that litter used as a fuel on the farm had an energy value of 4627 Btu/lb, an ash content of 23.73%, and a moisture value of 25.11% (see Appendix E for details on methods used for collection and analysis).

Solar panels (200 kW) also contribute to renewable energy production on the farm. Excess generation from the utility-interactive system is delivered to the grid via a net-metering program with the electric utility.

3. Objectives and Methods

3.1 Overall Performance Design Objectives

The objective of the performance evaluation was to determine the degree to which the Ecoremedy gasification unit achieved the following design objectives:

- Use poultry litter as a fuel to reliably deliver heat to poultry houses.
- Integrate seamlessly with the farm's existing propane-fired unit heaters and ventilation systems to maintain house temperature within industry-recommended (and grower established) targets.

- Reduce propane use on the farm.
- Run successfully with minimal operation and maintenance requirements (routine maintenance and daily addition of poultry litter fuel).
- Operate with no negative impacts on bird production and ideally improve bird health and production by allowing for increased winter ventilation and improved air quality.

3.2 Technical Performance Evaluation Methods

Temperature and humidity

Houses 9 and 10 were the smaller houses and had only three temperature sensors in each house. Houses 11 and 12 had five temperature sensors each and one relative humidity sensor. The farmer's house controllers and its sensors (Hired Hand Evolution computer controllers) were used for this data.

Energy consumption (propane and electricity) and delivery

The project team measured electricity load requirements for the Ecoremedy gasfier as well as farm propane use and energy delivered to the poultry houses. Propane meters (American Meter AL-425TCH-CF) were previously installed by the farmer to measure propane consumption for poultry houses. The Ecoremedy gasifier had its own propane tanks, and the bills were used to determine the amount of propane used during start-up. Utility meters were used to monitor whole-farm electricity consumption, while a GE I-210 electricity meter was used to monitor Ecoremedy gasifier system electricity consumption. The heat transfer is calculated every second using measured thermal fluid flow, the specific heat and specific volume of the thermal fluid, and the temperature difference across the boiler. The real time heat transfer is displayed on the control panel.

3.3 Farmer-supplied performance data

Farm staff used weekly log sheets to track operation and maintenance requirements, system run time and performance concerns, flock age, and their observations of in-house conditions. Metrics documented on the log included:

- Flock status (number of days from placement)
- Portion of the house occupied by the flock (partial/whole)
- Hours the system was operational (hours/week)
- Hours of farm labor needed to run the system over the week (operation and maintenance)
- Reasons the system was not run (e.g. heat not needed, maintenance problems)
- Description of any problems that occurred
- Amount of down-time due to system problems
- House conditions (heat distribution, dust level, ammonia odor)
- Propane meter readings

The farm owner also supplied information on previous farm energy use (propane and electricity), flock performance (via settlement sheets), and poultry litter production and use (on and off the farm).

Figure 4. Temperature sensor locations at Flintrock Farm for the two houses sized 44 feet x 500 feet (Houses 9 and 10)

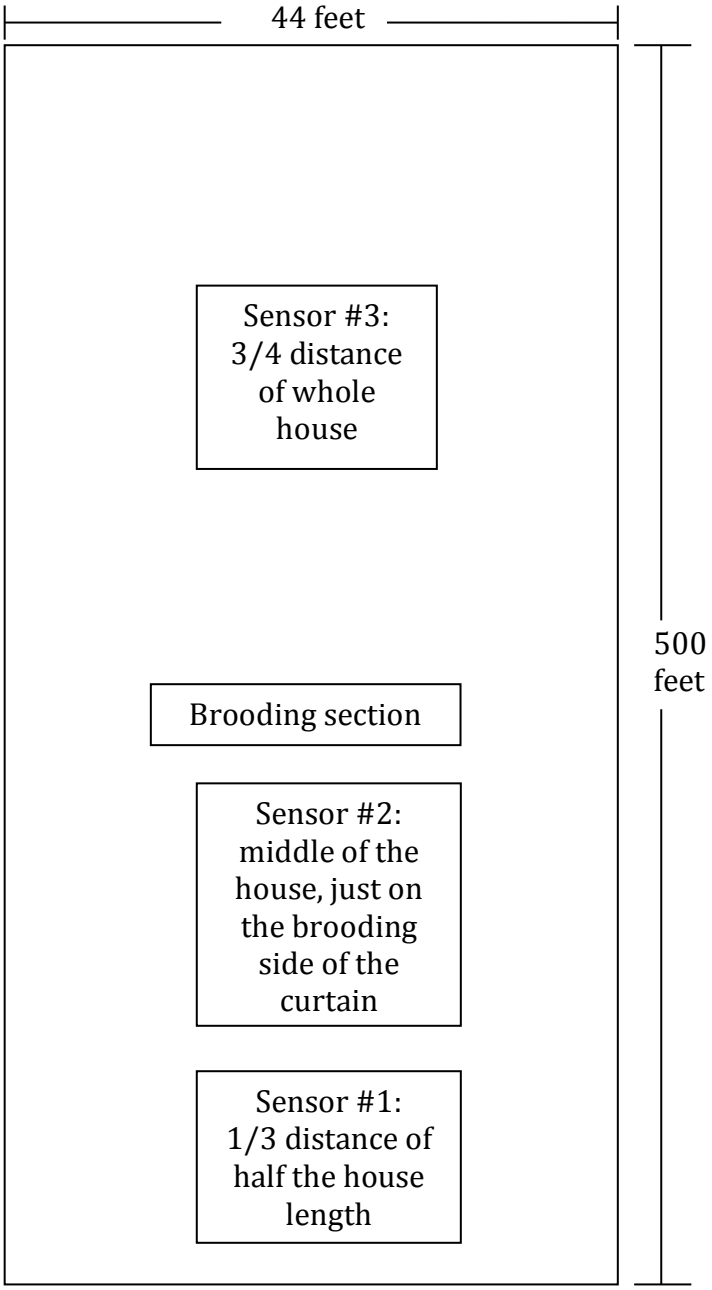
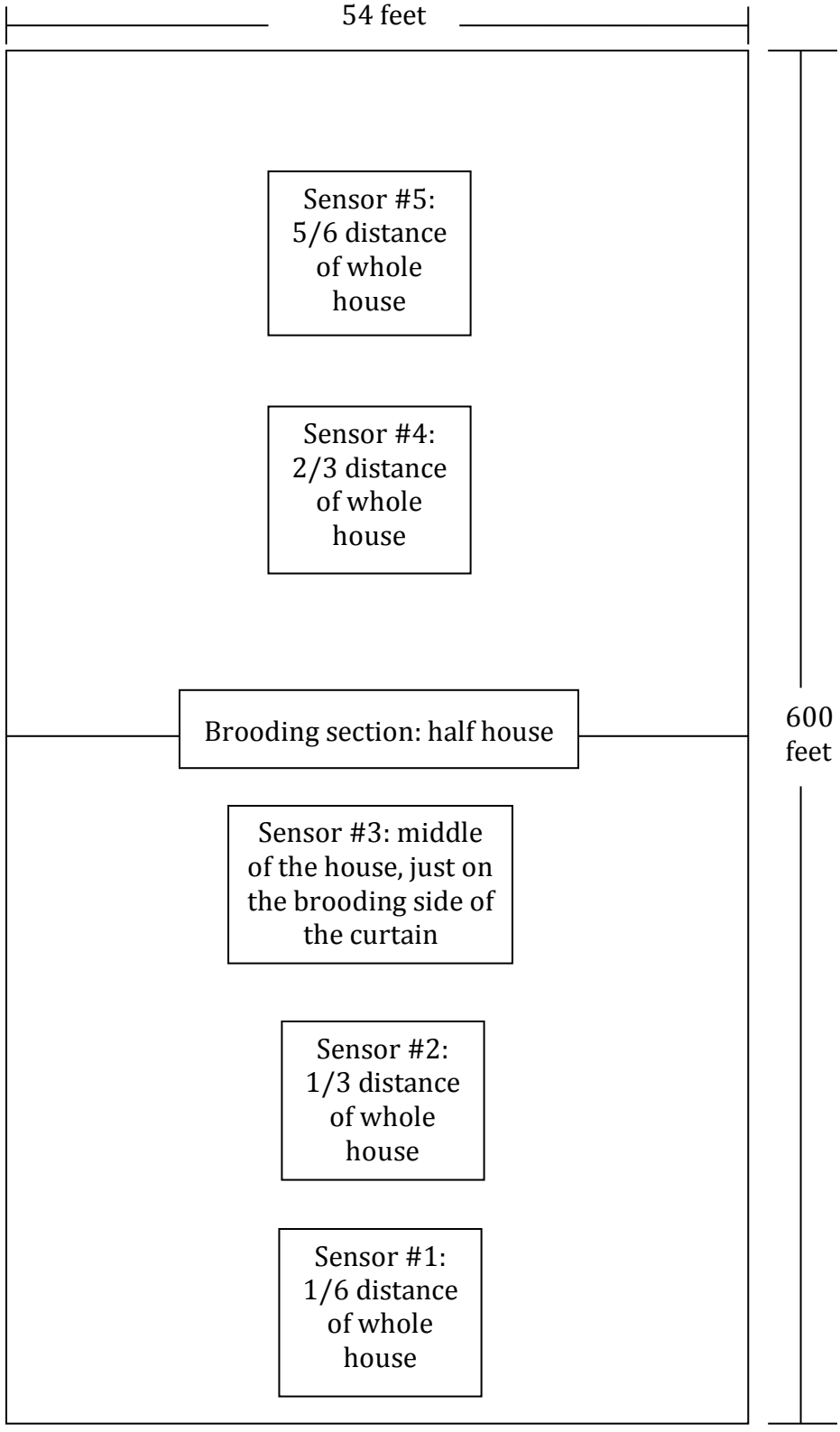


Figure 5. Temperature sensor locations at Flintrock Farm for the two houses sized 54 feet x 600 feet (Houses 11 and 12)



4. Performance Results

The system was installed during the summer of 2014, and the initial commissioning phase of the project started in late 2014. The project team defined commissioning as continuous operation without technical problems for one complete flock. As of November 2015, the vendor is still working with Flintrock Farm to achieve uninterrupted operation over a complete flock.

4.1 Reliability

Overall, the system will run for several weeks during a flock, but it requires several hours during operation and after shutdown for maintenance before the next flock, as shown in Table 2. Since installation, many of the issues have been resolved to reduce maintenance. However, there are still key technical challenges that impact system reliability (and steps that have taken to address them):

1. The screen on the chain grate routinely required repair between flocks, if not during a flock, and the under-fire grates clogged after approximately two of weeks of continuous use. To address this problem, the chain grate was redesigned to overlay the load bearing belt with a fine mesh screen to prevent the ash and litter from contacting the under-fire air holes. This change has improved air distribution and reduced clogging of holes in the perforated plates.
2. Rocks in the poultry litter resulted in repeated system shutdowns during the initial start-up phase. Rocks jammed in the de-lumper and/or jammed in the ash auger, causing damage to auger. Two strategies were used to address this problem. First, clean-out of the houses is done in a way that avoids the introducing rocks into the litter from the earthen floor. Also, the ash auger system was re-designed to reduce jamming and associated damage to the flighting. The flight thickness was doubled and the ash removal frequency was increased.

Table 2. List of technical major problems during the project and farm labor required to resolve

Description of Mechanical Issue	Farmer Time to Resolve (hrs)	Resolution and/or Recommended Next Steps
Boiler tubes fouling	Several weeks	Installed thermostats on heaters to keep boiler return temperature above 150^{o}F to reduce condensation of flue gas in boiler tubes.
Ash auger damaged	1-2 weeks	Ash auger flights were bent due to part of chain grate screen coming off and wrapping around flights. Replaced auger. Initially removed screen altogether, but recently reinstalled screen with a better quality attachment system
Rocks jamming de-lumper and ash auger	Happened several times, typically less than 1 hour to resolve; on-going	Initially, large rocks (1" diameter and larger) jammed the de-lumper and ash auger. Careful litter removal and ash auger redesign have helped, with only 1-2 interruptions per week max.
Baghouse clogging	Several weeks	Initial baghouse used for particulate matter removal clogged very quickly (hours to days) and was taken out of the system and replaced with two cyclones in series.
Incomplete ash	Several days/on-going	The system could not process the high moisture material (above 40% moisture) and the under-fire plates were becoming clogged. The litter is now drier, typically between 25-30% moisture. The under-fire plates still become clogged, and a final solution has not been implemented yet. The system runs, but the plates have to be cleaned between flocks.
Leaking connections on house heaters	2 weeks	The heaters had leaking fittings. The heaters had European fittings, which were not known at the time of installation. New fittings were installed and solved the leaks.
System not reaching designed output of 1.2 MBtu/hr (output is typically at 0.8 -1.0 Mbtu/hr)	On-going	Initial issue was high moisture litter with low Btu. Litter is now drier. Under-fire grates and chain grate also limited firing at higher feed rates. Newly designed screen is addressing this problem. Installation of emissions controls initially reduced output due to ID fan capacity. However, planned improvements to the system are expected to result in full capacity operation.
Screen on chain grate	On-going	A screen is used on the chain grate to help prevent clogging of the underfire grates. The screen material needs repairing or replaced after each flock or sometimes during the flock. A new screen design has improved air distribution and reduced clogging of holes in the perforated plates.

4.2 Heat Delivery, Temperature, and Relative Humidity

Table 3 shows the percentage of time that the system was providing heat to the poultry houses during five flocks. This capacity factor was calculated by adding up the total time the system ran during each flock and dividing it by the total flock time. Flock 4 only had 28% runtime as the system had a major failure in the chain grate system. Once a solution was found, the system ran more consistently during Flock 5. Flock 5 had only 45% run time, but the system did not need to run the entire flock time because the weather was much warmer and the houses didn't need heat. However, the amount of time that the houses did not need heat was not known and therefore was not used in this calculation.

Table 3. Capacity factor (percent of the time the unit was functioning correctly during each flock)

Farm Name	Flock 1 [9/15/14 – 11/3/14]	Flock 2 [12/5/14 – 1/26/15]	Flock 3 [2/3/15 – 3/24/15]	Flock 4 [4/2/15 – 5/21/15]	Flock 5 [6/8/15 – 7/27/15]
Flintrock Farm	0%	64%	57%	28%	45%

4.3 Energy Consumption (Propane and Electricity) and Delivery

Energy consumption and production for the Ecoremedy gasifier as compared to the propane heating system is provided in Table 4. Over the five-flock demonstration period, 25,082 MBtu of heat from both the in-house propane heaters and the gasifier was provided to the four poultry houses. The gasifier, which was not operated continuously through this period due to technical issues, contributed 6.6% of that total. Heat was delivered to poultry houses at an average rate of 0.66 MBtu/hour over the five-flock period. This heat output was 34-44 percent less heat output than originally planned (1.0-1.2 MBtu/hour).

To produce 1,661 MBtus of heat, the gasifier consumed 33.1 MBtu's of propane and 31,511 kWh of electricity. Electricity consumption consistently averaged 12.6 kW/hour of operation. Propane use was more variable, since propane is associated with start-up (e.g., the more often the gasifier is started during one flock the higher the propane consumption will be). Propane use varied over the course of flocks 2-5 (when the system was operational) from 0.04 to 0.19 gallons of propane/hour of gasifier operation.

Table 4. Operational performance data (propane and electricity consumption compared to heat delivery) for the Ecoremedy gasifer unit on Flintrock Farm compared to the existing propane heating system

	Ecoremedy Gasifier						Propane Heating System	
	Hours in Operation	Poultry Litter Rate (lbs/hr)	Propane Use (gallons)	Propane Use (MBTUs)	Electricity Use (kWh)	Heat Delivered to Houses (MBTU)	Propane Use (gallons)	Propane Use (MBTU)
Flintrock Farm								
Flock 1	0	200-300	93.7	8.5	0	0	n/a	n/a
Flock 2	868	200-300	34.8	3.2	10,936	678.3	2019	183.7
Flock 3	727	200-300	135.0	12.3	9,160	468.6	14,053	1,278.8
Flock 4	372	200-300	48.8	4.4	4,687	157.7	6,844	622.8
Flock 5	534	200-300	52.1	4.7	6,728	361.5	500	45.5
Total	2501		364.4	33.1	31,511	1,666.1	23,416	23,416.0

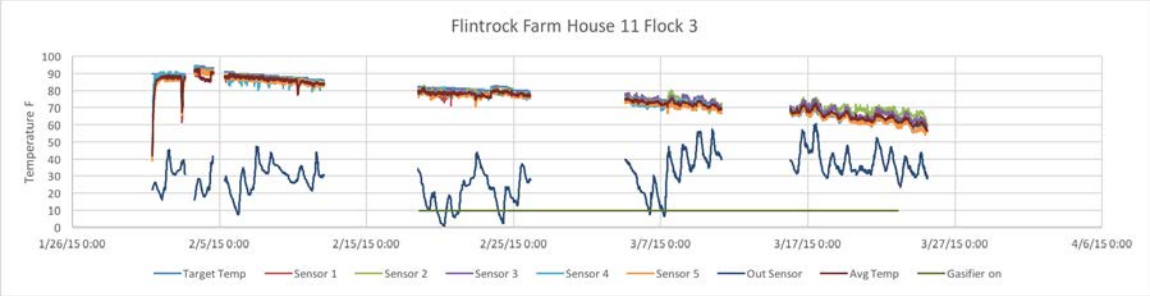
Data comparing the percentage of time the target temperature was achieved in the poultry houses when the gasifier was operational and when it as not is provided in Table 5. Performance for periods when the system was running (with the Ecoremedy gasifier) and not running (without the Ecoremedy gasifier) are included for comparison. Houses 9 and 10, the two smaller houses, were grouped together because they were the same size, as well as Houses 11 and 12 (the two larger houses). An example of temperature recorded by the sensors in one of the poultry houses is shown in Figure 6, which depicts sensor temperature readings and outside temperature over the course of one flock during a period of time when the gasifier system ran intermittently.

Table 5. Temperature and relative humidity performance in houses heated with the Ecoremedy system for the duration of the monitoring period (5 flocks). Houses are grouped by size (9 and 10 are 44 ft x 500 ft., and 11 and 12 are 54 ft x 600 ft.)

Farm Name (9/15/14 – 7/27/15)	Temperature Target			Relative Humidity Target		
	Achieved for the entire flock (%)	Achieved with Ecoremedy	Achieved without Ecoremedy	Achieved for the entire flock	Achieved with Ecoremedy	Achieved without Ecoremedy
H9 &10 *	55%	71%	44%	n/a	n/a	n/a
H11 &H12	61%	65%	58%	31%	47%	44%

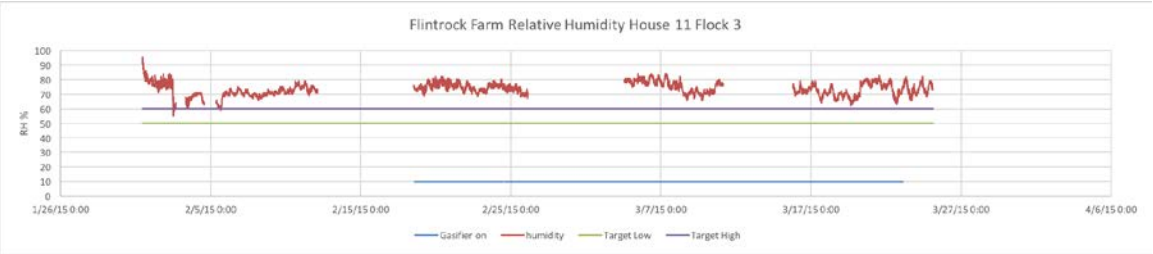
* Houses 9 and 10 did not contain relative humidity sensors.

Figure 6. Temperature readings from House 11 temperature sensors (five inside and one outside) compared to target temperature for periods when the gasifier ran intermittently



Relative humidity for the poultry houses fell within acceptable industry ranges 31% of the time (Table 5) for the entire flock with or without operation of the Ecoremedy gasifier. Figure 7 shows relative humidity over one flock from House 11.

Figure 7. Relative humidity in House 11 compared to target ranges over the course of one flock when the gasifier ran intermittently



4.4 Operations and maintenance

Estimated daily labor for filling the fuel hopper and checking the system is 1 to 1.5 hours. However, this is an estimate, as the system has had considerable start-up issues since installation that have required additional farm labor to address (Table 2). From November 29, 2014, through October 2, 2015, farm staff invested 564 hours in operations and maintenance.

5. Discussion

5.1 Reliability

The Ecoremedy gasifier installation at Flintrock Farm has had a longer than expected start-up period. While many of these have been addressed, this system is still in the early phases of demonstration. Many of the experiences that Flintrock Farm and the vendor have addressed provide valuable insight for future projects. For example:

- The conversion of the farm from conventional to organic production at the beginning of 2014 increased the moisture content of the poultry litter. The Ecoremedy gasifier system was designed to handle litter with up to 50% moisture, but the combination of the wetter litter, which has lower energy content, contributed to problems during the commissioning period. To address this issue, Flintrock Farm changed the way the litter is removed from the poultry houses. Specifically, litter below the water lines, which had much higher moisture than litter from the rest of the house, was scraped out and stored separately from litter used as fuel for the gasifier. This practice lowered the moisture content over the overall litter from the mid-40s to around 30%.
- The initial problems related to the boiler fouling — a common problem for biomass-fueled combustion systems — was addressed by increasing the temperature of the water in the boiler. Thermostats were installed at the house heaters to limit their use if the return boiler water was too low (around 150°F). After the thermostats were installed and after a few adjustments, the boiler fouling problem was solved. One important lesson was to keep the water temperature in the boiler above 150°F to prevent condensation from occurring on the gas side of the boiler tubes.
- Rocks (or other solid debris) in poultry litter are a ubiquitous problem and will impact material handling systems for most manure-to-energy projects. Both equipment design and on-farm management strategies were used at Flintrock farm to minimize equipment shut-down and damage. Like most poultry houses in the region, poultry litter on Flintrock Farm is placed over a bare dirt floor. During whole-house clean out, they now leave about ½ inch of litter in the houses to avoid scraping the dirt floor. Also, litter from the center of the house, which has fewer rocks than litter from the house perimeter, is used for fuel. Heavy equipment traffic has packed the dirt floor of the center of the house (whereas stones are more likely to mix with litter closer to the house walls where the floor dirt is more loosely packed). Also, the vendor doubled the thickness of the flights of the ash auger and increased the frequency of ash removal. This resolved problems previously experienced with flights being folded flat by rocks.

According to Dan Heller, owner of the Flintrock Farm, “this is a process and a journey, and we definitely haven’t arrived at a final destination yet… We are continuing to invest in refining the system with the hope that we can continue to improve the system. We are

making progress. The technology does work. The question is, can we make it reliable enough so that it is worth the effort? We have days where it runs great, but days where it requires maintenance. We are hopeful that changes they are making will result in smooth, uninterrupted operation."

5.2 Heat Delivery, Temperature, and Relative Humidity

Variation in temperature between the sensors suggests that, over the course of five flocks, there were periods in which the Ecoremedy gasifier had better temperature performance than when the gasifier was not operational (71% versus 44 % in Houses 9 and 10, and 65% versus 58% in Houses 11 and 12) (Table 5). Relative humidity results were similar for periods when the Ecoremedy gasifier was operating (47%) and when the system was not operating (44%).

However, these results are not sufficient to determine whether these observed improvements are the result of the gasifier heating system, or some other contributing factor. Over this performance monitoring period, technical and material handling issues compromised performance so that the gasifier provided only 6.7% of the total Btu's delivered to the poultry houses over a five-flock period. Additional monitoring would help to determine whether heat delivery improves with design modifications, and whether temperature and relative humidity results are consistent over time and with changes in the percentage of the total heat delivered by the gasifier.

5.3 Energy (Propane and Electricity) Use and Delivery

Even with intermittent operation and performance below design goals, the Ecoremedy gasifier produced far more energy than it consumed via electricity and start-up propane. However, start-up issues previously discussed (technical and material handling) undermined heat output of the gasifier system.

5.4 Operation and Maintenance

Farm labor requirements were far higher than anticipated, despite the vendors' dedication to resolving issues in a timely manner. This is similar to what the Farm Manure-to-Energy Initiative team has observed with other first-time demonstration projects, and it is something both farmers and technology vendors should be aware of. For this project, close proximity of the vendor to the farm, as well as the vendor's commitment to the project helped to facilitate repairs. If technical and material handling issues are resolved on this farm in such a way that translates to other projects, this initial labor investment should be minimized on future projects.

6. Vendor Comments

Each manure-to-energy technology vendor was provided with the opportunity to provide comments for inclusion in this report. The following comments are authored by Ecoremedy Energy:

Enginuity Energy is appreciative of the opportunity to work with Flintrock Farm and the Farm Manure-to-Energy Initiative to install the Ecoremedy advanced gasification system. We thank all parties for their cooperation and patience throughout the project.

We've learned a great deal through this project and have improved the equipment design for easier maintenance and longer operation without incident. Specific improvements include:

- A revised gasifier chain grate design that supports the fine particles of litter and tiny gravel size stones on top of the load-bearing belt. This simple change dramatically improved the belt integrity and reduced clogging of under fire air perforations.
- Although the new grate design dramatically reduced clogging of the under fire gasification air nozzles, future air perforations will be tapered to prevent bridging of any tiny stones within the air hole.
- In an effort to reduce equipment cost for farm-scale application, we elected to remove the gasification air preheater from the original scope of supply. Years of operating history in GA and at our R&D facility installed on the Harrisburg Area Community College campus in Harrisburg, PA, provided reason to believe we did not need an air preheater. We learned an air preheater is paramount when dealing with aged litter and other composted manure fuel feedstock.
- Automatic ash removal augers will be installed under the return chain to eliminate the need to temporarily empty ash from under the gasifier than has been deposited during the return trip of the chain grate.
- An improved guillotine gate assembly that includes a motor driven actuator with dual drive screws.

The above mentioned design changes will significantly improve operational uptime. Some lessons learned regarding the overall system for farm scale installations:

- Careful management of litter collection is mandatory. We experienced many large rocks the size of a fist or a cell phone that caused downtime due to a jammed lump buster, often resulting in damage to equipment. Rocks that are smaller than golf balls are processed without problem.
- Nutrients in aged litter are concentrated compared to litter that is removed after each flock. The concentrated levels of potassium chloride (KCl) in aged litter results in higher levels of fly ash precipitate than in single flock litter. It is important to note the distinction between precipitate fly ash and carry over fly ash. Precipitate fly ash actually precipitates out of the flue gas stream when it cools within the boiler compared to a mechanical carryover of fly ash due to combustion or improper

gasification. The higher KCl precipitate fly ash levels require extreme care to operate the oxidizer below the ash fusion temperatures to avoid fouling within the boiler. Our operational uptime dramatically improved when we learned to keep the oxidizer below 1700°F.

- A baghouse is a poor selection for a farm-scale project where shutdowns occur between flocks. The high moisture content of the feedstock coupled with an outdoor installation resulted in condensation within the baghouse and immediate fouling of filter media. Operational costs to properly preheat the baghouse before start-up and again during shutdown are cost prohibitive for farm scale operations.
- Mechanical collecting using cyclone collectors is a nice primary dust collection method but not sufficient as the only collection method. Our fly ash particle size is less than 5 microns, which is very difficult to capture with a mechanical cyclone.
- Indoor installation in a controlled environment is absolutely necessary. Our gasification system is an outdoor installation exposed to the weather and other problematic elements. Controls and equipment do not perform well in such extreme temperatures and corrosive conditions. We will not make this mistake again. Flintrock has enclosed the gasifier/boiler and controls room since the initial installation.

The Ecoremedy technology successfully performed under challenging conditions:

- Although designed originally for litter with different properties, we are successfully gasifying aged litter from organic chickens with higher moisture content, lower energy content, and higher bulk density than originally specified.
- Our system is exposed to the outside elements. Installed within the litter storage facility, the prevailing wind blows across the litter metering equipment and conveyors covering all equipment and controls with fine litter and dust. We operated in temperatures below 0° F for many consecutive days. This was poor judgement to attempt to install and operate in such an environment.

We wish to make two comments regarding the overall performance levels of the Ecoremedy gasifier and the Enginuity Energy LLC team:

- The outdoor installation created many problems for the equipment. Particularly damaging was the historic cold temperatures during the 2013 and 2014 winters. The outdoor installation without gasification air preheater coupled with below zero temperatures made it extremely difficult to achieve targeted performance levels. We have subsequently installed a small heat exchanger around our boiler exhaust stack in an attempt to raise the gasification air temperature by 100°F. This has proven to improve the unit performance. Flintrock Farm has recently enclosed the boiler room, increasing the temperature within the room and protecting the controls from frigid temperatures and corrosive dust. We anticipate this will result in further performance and maintenance improvements.

- AFTER all the equipment was ordered and delivered to site, we were notified that our previously approved location for installation was no longer approved requiring an addition to be built onto the existing litter storage barn to house the gasifier and boiler system. This delay resulted in the expiration of all equipment warrantees BEFORE commissioning. When we experienced problems that were rightfully covered under OEM warranty, all claims were denied due to expired warranty period. Enginuity Energy was forced to incur significant out-of-pocket expense not anticipated to repair/replace equipment that would have otherwise been covered, or partially covered, under warranty. This resulted in longer response time and repair time.

7. Recommendations and Next Steps

The Ecoremedy gasification system on Flintrock Farm is still in the early phases of demonstration and warrants additional monitoring. Successful demonstration should be achieved at Flintrock Farm before the system is installed on additional farms.

In the vendor comment section, Ecoremedy Energy identifies a number of strategies planned for implementation on this farm that will improve technical performance. Next steps for air emissions control equipment are discussed in Appendix E of the final report.