

Technical Performance: Total Energy Blue Flame Boiler Heating System

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

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1. The Technology

The Blue Flame Boiler Heating System by Total Energy Solutions uses three main components for a complete manure-to-energy hydronic heating system:

1. The material handling equipment for litter and ash
2. A Blue Flame Stoker Boiler combustion unit that uses poultry litter as the feedstock
3. A hydronic heating system using CUBO brand heaters in the poultry houses

The system uses an off-the-shelf litter spreader (BBI, 24 ft. truck-mount spreader box without the spinners and the drive) converted to an electric drive. The litter is then conveyed from the litter spreader via an auger to the Blue Flame's surge hopper.

The Blue Flame stoker and boiler unit (Model CGS-W-M700) is a standard off-the-shelf combustion unit initially designed to be fueled with wood or coal, but which is now being fueled by poultry litter. With a maximum output capacity ranging from 1.5–2.0 MBtu/hr, this unit has approximately an 8:1 turn-down ratio, meaning it uses the poultry house temperatures to control the feed rate of the boiler, which in turn controls the heat output. When the houses call for more heat, the boiler ramps up; when the houses call for less heat, the boiler ramps down.

Within the Blue Flame stoker unit, a twin-screw feeding system meters the litter onto the moving chain combustion grate. Combustion is facilitated by a combination of underfire and overfire air, controlled by a programmable logic controller (PLC) to maximize efficiency and reduce emissions. The combustion process takes place all in one chamber above the chain grate. The oxidized flue gases then travel through a triple pass boiler where hot water is heated.

In this case study, hot water exiting the boiler is piped into two poultry houses heated by previously installed Modine (V/VN-279) downdraft hot water heaters (three heaters in the 10,000 square foot barn and four heaters in the 20,000 square foot barn).

From the boiler, the flue gasses pass through a set of cyclones to control emissions. The ash from the combustion chamber and the fly ash from the cyclones are automatically removed from the system and emptied into a dump hopper that the farmer must empty periodically.

This system was installed in the summer of 2015. It replaces and improves upon an older Blue Flame stoker and boiler heating system originally installed with funding from the National Fish and Wildlife Foundation in 2009; it delivered heat until 2014, when an electrical fire in the electrical distribution panel (not associated with the Blue Flame system) damaged this unit beyond repair. Insurance covered the replacement cost, and funds from the Farm Manure-to-Energy Initiative, Total Energy Solutions, and Windview Farm were used to improve system performance, based on lessons learned over the previous years.

The 2015 installation included design improvements that enhanced the system:

- The combustion section is now separate from the boiler section, which improves combustion efficiency and heat transfer to the water. The new boiler also has a remote monitoring capability — the programmable logic controller (PLC) — allowing updates from the factory and remote monitoring of the boiler performance.
- Mr. Curtis requested that the ash auger system be designed with an open U-trough (instead of a closed tube) to facilitate flow of rocks or other larger material (often associated with poultry litter) through the system. Previously, rocks would get jammed in the ash auger and shut down the system.
- The original hot water distribution system was completely removed and replaced. The original system used independent supply and return water lines and pumps to deliver hot water from the boiler to each Modine heater. The original demonstrated problems associated with pump and pipe sizing, which significantly compromised delivery of hot water to heaters located at the end of the poultry houses.
- The new design uses one sensorless, variable-speed pump located in the boiler room along with a single supply and return line to each poultry house. Each heater is now individually tapped off of the supply-and-return line. He also replaced underground piping to the houses with a heavy duty, pre-insulated, large-bore PEX pipe (3 in., Logstor).

Currently, the pump operates on a continual basis supplying hot water to the heaters at a steady rate. However, the farmer is considering installation of actuator valves that will allow for variable pump speed based on the heat requirements of the house. This change will improve energy efficiency. For example, energy requirements will be reduced from 5 HP to $\frac{3}{4}$ HP during periods of low heat-demand.



Figure 1. Litter spreader emptying into auger (left of picture).



Figure 3. Blue Flame stoker and boiler. The boiler sits on top of the combustion system.

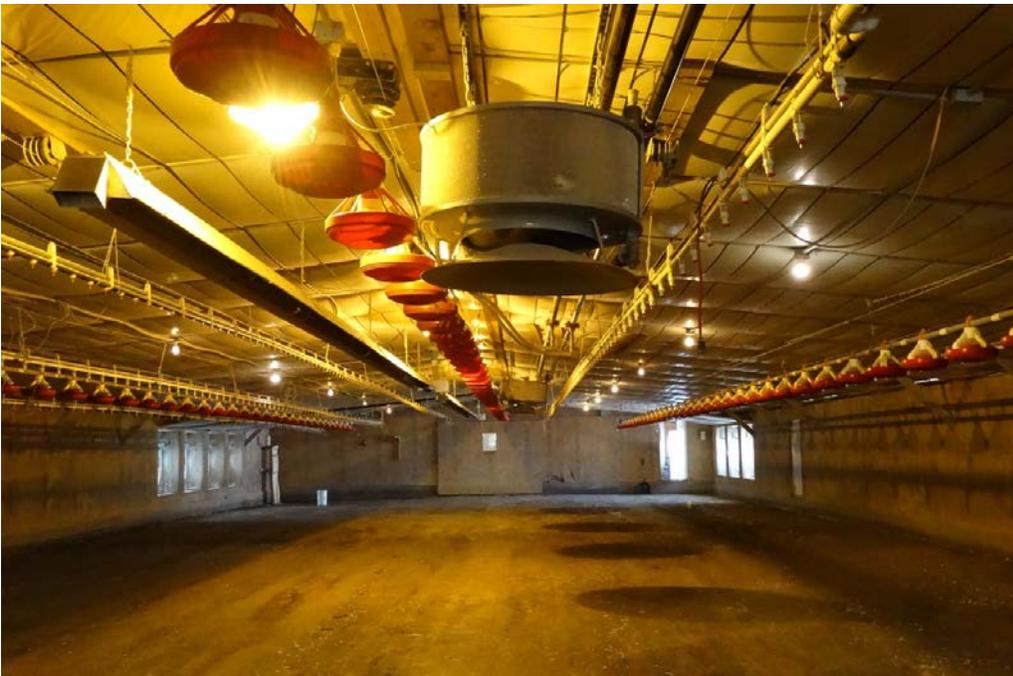


Figure 3. Modine heaters used in poultry houses.

2. The Farm

Windview Farm in Port Trevorton, Pennsylvania, grows approximately 440,000 anti-biotic free broiler chickens per year for Sullivan's Natural in two poultry houses. Each building consists of a 10,000 ft² section and a 20,000 ft² section, for 30,000ft² per building, or 60,000 ft² total. The farm places six to seven flocks per year with an average flock cycle of 40 days. Broilers are grown to varying weights depending on market demand.

The operation produces approximately 375 tons of poultry litter a year. Based on the farm's nutrient management plan recommendations, up to 2 tons per acre (for corn) are applied to 40 acres owned by the farm and an additional 100 acres of rented land. The application rate varies according to the crop production cycle, with corn and soybeans planted in rotation. Remaining poultry litter is exported off the farm.

Analysis of the poultry litter indicates that the energy value is 5,635 Btu/lb, the ash content is 12.53%, and the moisture value is 29.75% (for details on collection and analysis methods, see Appendix E). As required by the farm's integrator, the poultry houses are completely cleaned out between each flock, and old litter is entirely replaced with fresh litter. This is unusual, as most poultry growers scrape or "crust" out the top layer of litter between flocks, limiting whole house clean outs to once every very years to reduce costs associated with purchasing replacement bedding.

3. Objectives and Methods

3.1 Overall Performance Objectives

- Using poultry litter as a fuel, reliably deliver heat to poultry houses.
- Integrate seamlessly with the farm's existing propane and ventilation systems to keep house temperature within industry-recommended guidelines.
- 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 Evaluation Method

Because installation of the new Blue Flame system took place during the summer of the last year of the project, the Farm Manure-to-Energy Initiative team was not able to collect monitoring data. However, the previous system had been used successfully on the farm for five years prior to being damaged in a fire. The technical performance discussion is based on prior operational history and one flock of operation during the 2015 cold weather season.

4. Performance Results

4.1 Reliability

The original Blue Flame boiler and heating system has operated for just over five years without any major problems. However, Mr. Curtis advises that it took a few flocks for him to learn how to operate the system and how to manage his litter in order to produce a good quality fuel for the boiler. The system has had only one failure in five years (a fan motor that had to be replaced).

The new system has been operated for one complete flock since the system was installed. According to Mr. Curtis, the changes made to the system have improved performance. He says they have plenty of hot water. He also observed that the U-shaped ash auger has reduced system downtime associated with rocks getting caught in the ash removal system.

4.2 Temperature and Propane Reductions

During the first few flocks of full time operation of the Blue Flame boiler, the amount of propane used was reduced by 90 percent. Even with 20-degree nighttime temperatures, the system generated 100% of the heat needed by the houses.

4.3 Operations and Maintenance

Mr. Curtis estimates that the system requires about 45 minutes per day to operate, including loading four bucket loads of poultry litter into the fuel feed hopper and unloading the ash. On colder days, operational time increases to one hour. This also includes removal of foreign debris from the litter.

According to the Mr. Curtis, the key to reliable operation of the system is managing the litter for good fuel quality. The drier the fuel, the better it will burn. Currently, the farm's integrator requires whole house clean outs between every flock. However, Total Energy Solutions recommends this approach for all farms using this system to improve performance and reliability.

Mr. Curtis also notes that while he has become very good at managing his litter, he has not been able to eliminate foreign objects like large rocks completely. Hence, on occasion, additional maintenance is required to remove a stone from the ash auger.

While the boiler system requires very little maintenance for things like greasing, the house heaters do require cleaning because of dust on the heat exchanger surfaces. Compressed air is used to blow the fans off a few times a week.

The system also requires attention upon shutdown to keep the boiler water temperature and the flue gas temperature close to each other to prevent condensation in the boiler tubes. A slow controlled shutdown is preferred, which takes a couple of days, but it only requires an extra 1-2 hours of monitoring by the farmer.

5. Discussion

With five years of operational time, the Blue Flame stoker and boiler heat delivery system is the longest-running poultry litter-fueled energy system in the Chesapeake Bay region. With this system, Mr. Curtis has realized significant fuel savings. For the newly installed system, now run for one flock, Mr. Curtis says that he is “extremely impressed.” He notes that “the litter is dry and the foot pads are good” and that “I don’t know that I would change anything. It is working extremely well.”

However, the requirement for whole house clean-out between every flock will likely be a concern for some growers. Because wood shavings used as bedding are expensive, most poultry farms in the region “scape out” or “crust out” between every flock, which entails removing the top layer of the litter only. Additional time and expense associated with whole house clean-outs between every flock would need to be taken into account in the operations and maintenance requirements for this system.

Blue Flame does offer a range of units as small as 1.0 to as much as 16.0 Mbtu output with poultry litter, making this system adaptable to farms of various sizes. Because the system delivers heat via hot water, there is some flexibility with respect to where the unit is located with respect to the poultry houses, although minimizing the distance reduces infrastructure costs.

As discussed in the air emissions chapter of the final report (Appendix E), Total Energy Solutions is working with emissions control experts to reduce particulate matter and nitrogen oxide emissions so that this technology can be installed in all the Bay states. They are focusing on emissions controls that are cost effective while meeting current permitting thresholds throughout the region.

6. Recommendations and Next Steps

Based on feedback from experts in poultry ventilation, this system is ideally suited to support improved cold-weather ventilation and house air quality, as well as providing a source of dry heat. There is currently very little published data on the impacts of this type of thermal manure-to-energy heating system on bird production. Because each of the Windview Farm poultry houses has two separate sections, this farm would be ideally suited for on-farm research to evaluate the impact of a poultry litter-fueled heating system on key poultry production metrics. These metrics could include growth rate, feed conversion, bird health, litter quality, paw quality, in-house air quality, etc.

As previously discussed, Total Energy Solutions will continue to work with project partners to improve air emissions and support expanded adoption throughout the region.