Poultry Litter Combustion on the Eastern Shore of Maryland: Case Study

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Fluidized Bed Combustion (FBC) Overview

Biomass Input	Poultry Litter
Year commissioned	2016
FBC Thermal Energy output capacity	600 kWt
FBC Electrical Energy output capacity	65 kWe

Farm details and litter management

- Four poultry houses
- Conventional space heating using Liquefied petroleum gas (LPG) combustion.
- Excess litter transported off-site or land applied as a fertilizer.

Figure 1. Fluidized Bed Combustion system

Fluidized Bed Combustion:

Reason for FBC Installation

Land application of poultry litter as a nitrogen source simultaneously results in three to four times higher application of P than the crops need. Leaching of nutrients from these soils over the years has contributed to the eutrophication of the Chesapeake Bay. The goal of the technology was to produce energy from poultry litter and create an ash byproduct for use as a fertilizer or soil amendment. The thermal energy generated by the combustion of the poultry litter was used to heat up the poultry houses by replacing LPG. It was also expected that the drier heat would help improve bird health. The excess heat was used for electricity production.

System description

An Energy Center building housed the FBC unit, the generator, an Organic Rankine Cycle (ORC) unit, and fuel handling system. The litter was stored in a storage shed before being fed into the FBC system using a sensor-controlled scraping system connected to a conveyor belt.

Process description

The combustion system employed a fluidized bed technology where multiple streams of hot air were used to suspend the fuel particles that were combusted within the furnace. The fluidization of the particles caused an increase in surface area due to the constant turbulence and breaking up of larger particles into smaller sizes. This increased surface area lead to improved contact between the particles and oxygen in air.

FBC Performance

The FBC system produced an average **1,534 kWh of total energy per ton of poultry litter (wet mass)** over six flocks averaging 0.176 metric tons/hr feed rate into the FBC system, with a 30% annual runtime and 568 tons of poultry litter combusted. This produced energy is equivalent to 942,000 kWh of thermal-only energy (1,660 kWh per ton of poultry litter combusted) or 141,000 kWh of electricity-only (249 kWh per ton of poultry litter combusted).

If the unit had operated at a higher run-time (0.246 tons/hr feed rate into the FBC system, 77% yearly runtime with 1,655 tons of poultry litter combusted), the unit would have produced 1,985 kWh of energy (thermal + electrical) production per ton of poultry litter combusted, which is equivalent to 2,610 kWh of thermal-only energy per ton of poultry litter combusted or 391 kWh of electricity-only per ton of poultry litter combusted.

Nutrient Budget

Assuming a 100% mass conservation of P and K, a mass reduction of 86% would have been expected with a total ash production of 144.1 kg of ash per ton of wet poultry litter. The wet poultry litter contained 24.1 kg of N, 19.8 kg of P (as P_2O_5), and 24 kg of K (as K_2O) on a per ton basis. The ash product contained an estimated 144 kg of P (as P_2O_5), and 163 kg of K (as K_2O), with negligible concentrations of N, on a per ton basis.

Life Cycle Assessment

The life cycle assessment of the FBC system showed that it can lead to **32% lowered impacts on greenhouse gas emissions compared to LPG usage**. However, the process was not effective at lowering freshwater and marine eutrophication potential. Assuming the system operated under improved operational conditions, **the reduction in greenhouse gas emissions and freshwater eutrophication would have been 77.4% and 75.7%**, respectively, compared to LPG use for poultry house heating. It should be noted that the LCA study did not include the impacts of land application of poultry litter and the ash product due to the large variation in emissions caused by factors such as manure characteristics, application management, soil conditions, and environmental factors.

Lessons Learned

- Frequent communication and specific, written expectations of each party throughout the project is integral to a successful project. There needs to be a consistent point-person throughout both the implementation and monitoring periods to communicate with the farmer, MDA and monitoring representatives on project changes, concerns, and expectations, including responsibilities for land, equipment, and operation after the required monitoring period is finished.
- The quality and characteristics of the feedstock need to be carefully tested before system design and installation. Poultry litter contaminated with foreign objects can cause damage to the FBC unit and result in increased downtime for repairs.
- The poultry litter characteristics on a specific farm need to be considered before

project commencement. The FBC can combust fuels with heating values (LHV) under ideal conditions of 8 MJ/kg, with a tolerable range of 7.5 MJ/kg plus (LHV), and an ideal moisture content of 40%, with a tolerable range of 35 to 45%.

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