A BIOMASS ENERGY PROCESS FOR POULTRY GROWING OPERATIONS

Jim Neathery, Ph.D.[1]

[1] President, Neathery Technologies, Inc.
jim@neathery-tech.com www.neathery-tech.com

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Problem Statement

According to the USDA, over 45 billions pounds of poultry (or approximately 8.7 billion birds) are produced annually in the U.S. A majority of this production is from concentrated animal feeding operations (CAFOs) as shown in Figure 1. Many agricultural communities in the mid-south have seen a rise in the number of CAFOs. Across the tobacco belt in the southern region, many farmers are converting their tobacco farms into contract poultry growing operations. A large portion of these growing operations are located in the mid-west (EPA region 7) and the south (EPA region 4).

In a typical poultry farm, birds are grown out in houses enclosing over 20,000 ft^2. The scale of these operations can vary from 3 to 24 houses. Starting with each grow-out period, a fresh bedding material, consisting of 6-8" wood mulch, is spread over the house floor. Over the course of the grow-out phase, the bedding material absorbs manure and provides insulation from the cold. Once the birds are mature and harvested, the bedding material has become poultry litter (PL) and is removed. Assuming 200 tons of is litter removed per flock; up to 87 million tons of poultry litter is produced annually in the U.S. This material is considered an excellent low-cost compost fertilizer and is typically marketed to farmers for direct application on fields.

Figure 1. Typical Poultry House

Technology Description

In the current project, we intend to develop a small-scale gasifier system to convert poultry litter biomass into a clean gaseous fuel that can be used onsite. A central gasifier unit could supply fuel to an electrical generator and existing poultry house heaters. A portion of the gasifier ash will be utilized to scrub the producer gas of trace pollutants such as HCl and H_2S. The remainder of the residual ash can be economically marketed outside the growing area as a concentrated 0-24-16 (N-P-K) fertilizer. The goal is to displace a large portion of the natural gas or LPG usage and thereby lower non-renewable carbon dioxide emissions.

The key technical issue is determining the properties of the gasifier ash formed at greater than 800 °C. The ash alkalinity (as CaO and MgO) will determine the acid gas adsorption capacity. Equilibrium calculations using data from poultry litter ash mineral analyses show that the quantity of ash generated is excess of the requirement to clean the fuel gas of HCl and H_2S. Based on equilibrium calculations, only 10-15% of the total gasifier ash will be needed as a sorbent for HCl and H_2S. However, the fraction of ash required for the adsorber will depend primarily on its "available" alkalinity.

Figure 2. NTI's Experimental Gasification Prototype

Expected Results

The characterization of the chemical/fuel properties of the PL feedstock will be crucial in determining the size of the trace gas adsorption reactor and the subsequent reactor required for the oxidation of the sulfided sorbent to sulfates.

The economic feasibility of the proposed concept will depend heavily on the utilization of excess fuel gas. The heating requirements of the poultry houses accounts for only 10-20% of the total thermal content of PL; therefore, the excess will be available for other uses such as power generation.

Therefore, the Phase I objectives are summarized in the following:

- Characterize the chemical and physical properties of poultry litter and respective ash. A bench-scale gasification prototype (shown in Figure 2.) is being used to generate ash and char for the project;
- Determine the optimum reactor types for the adsorber and oxidizer;
- Develop a refined flow sheet and design for the hardware needed for a Phase II demonstration;
- Determine economic feasibility of utilizing PL-derived fuel gas in existing power generator hardware; and
- Develop a plan and hardware list for using PL-derived fuel gas for firing existing and/or new heaters in a poultry growing house. Additionally, develop a dual fuel (fuel gas/diesel) system for the existing diesel powered electric generators.

Potential Environmental Benefits

The emission of ammonia from broiler houses and from litter compost has the potential to affect the local environment in localities near the poultry growing operations. If the litter is used as a soil amendment, a large percentage of the organic nitrogen (60-90%) is converted to ammonia within a year. A portion of the gaseous ammonia (NH_3) is ionized to $(NH_4)^+$, which is water-soluble. NH_3 gas is emitted to the atmosphere while $(NH_4)^+$ can be transformed by microbiological nitrification to nitrate. Nitrate is highly mobile and can become an environmental problem in runoff waters. Using the above figures, and considering PL has total nitrogen content of 3.5wt%, annual ammonia emissions in the U.S. due to PL land disposal is over 8 million tons (as NH_3).

The marketability of PL compost is limited by transportation costs (typically less than 30 miles from the poultry facility) due to its relatively low nutrient density of nitrogen, phosphorous and potassium. Consequently, direct land application is usually limited to areas near the poultry growing operation. Since poultry litter is richer in phosphorus than nitrogen and potassium, repeated local application of the compost may lead to excessive phosphorus build-up in soils.

With the current gasification concept, the byproduct ash and char could be marketed as a concentrated fertilizer. Assuming that a mid-sized poultry farm produces 500 tons/yr of ash, the farmer could be sell the value-added material as a fertilizer (0-24-16, N-P-K) for $100 per ton. Since the nutrients in the PL are concentrated after gasification, the transportation costs are considerably lower, thereby increasing its marketable radius as fertilizer byproduct and decreasing the local application to farm fields.

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