Manure to Energy Feasibility Study For Duncannon Borough

Funded by: The Chesapeake Bay Commission

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EXECUTIVE SUMMARY

Introduction

Studies have shown that past and current agricultural practices have led to an increase of nutrients to the Chesapeake Bay. At the same time, agriculture has changed dramatically over the past several decades to monoculture. With manure becoming concentrated on areas of limited acreage, the utilization of the manure has become more difficult. As a result, specific areas throughout the country have been identified as having excessive nutrients.

The issue with excessive nutrients has resulted in the need to find alternate uses for this agricultural residual. One alternative use is electricity generation from manure. The use of manure for this purpose offers numerous benefits including a potential reduction in nutrients reaching the Chesapeake Bay, a step towards the goals of the Alternative Energy Strategy Portfolio, and an outlet for farmers to dispose of excess manure.

This feasibility report is the result of a grant project from the Chesapeake Bay Commission with the following tasks:

- Identification of stakeholders;
- Collaboration with Five Winds International on the Life Cycle Assessment;
- Identification of potential credit trading;
- Evaluation of technology; and
- Recommendations for future funding.

The Scenario

The feasibility study was developed around a hypothetical scenario in which a manure to energy power plant would be constructed within or near Duncannon, Pennsylvania to provide approximately 2 megawatts (MW) of electricity for the residents of Duncannon Borough using poultry litter as a fuel source. Poultry litter would be trucked from manure exporting poultry farms within a 50-mile radius of Duncannon (see Appendix 1). However, it may be economically feasible to obtain fuel from as large as a 100-mile radius depending upon transportation costs. Readily available wood waste would be added to the poultry litter to create a uniform fuel which combusts more efficiently. The proposed mix would be 70% poultry manure and 30% wood waste. The plant would generate electricity for the residents of Duncannon Borough and any excess could be sold to the grid to create additional revenue. A Life Cycle Assessment (LCA) was completed to present the environmental and economic feasibility for a 2, 5, 7, and 10 MW plant.

This report presents information on several topics:

- Biomass fuels:
  - Types of Biomass
  - Availability and flexibility
- Technology analysis which details the benefits and drawbacks of various types of electricity producing technology associated with poultry manure and wood waste.
- Plant Operation and the components that go into a functional electric generation plant.

- Economics of a manure to energy plant which include an evaluation of investment based on a seven year return on investment (ROI), use of a steam host, and the benefit of selling excess electricity to the grid.
- Potential site location within the Borough of Duncannon and surrounding area.
- Benefits of a manure to energy plant which include the local, regional, and global arenas. Additionally, there are benefits which apply specifically to the Borough and the Chesapeake Bay.

Findings

- For the plant to make economic sense, there are a few items that must be considered. One of the most apparent costs associated with the plant is the cost of trucking the manure to the plant. For that reason, an estimate of a 50-mile radius was used in the economic assessment. Additionally, the utilization of a steam host near the plant could offer a significant revenue stream.
- The Life Cycle Assessment (LCA) found that environmental impacts are lowered if the plant is used to produce power and thermal energy. The assessment also found that the pollution created by trucking of poultry litter is low when compared to the entire process. Global warming potential is projected to decrease with this type of plant. Additionally, optimization of current agricultural practices is greatly improved.
- All potential locations for site placement come with positives and negatives. At this point in the process, it appears that the Ballfield Park or the Business Campus One sites would offer the best options for building a manure to energy plant. These sites were chosen based on their accessibility, infrastructure, proximity to the public, and ability to be controlled by the Borough of Duncannon.
- Based on a review of numerous technology types, combustion and/or gasification have the desired qualities for this project. For the long-term success of a plant of this type, it is crucial that the technology have the ability to utilize several different fuel types. Combustion is one of the most proven and adaptable technologies.
- Because of the efforts of the Chesapeake Bay Strategy, the Alternative Energy Standard Portfolio, and the Energy Independence Strategy, there are several sources of funding which could help to support a manure to energy plant. These funding sources are comprised of grants, venture capitalists, and energy companies.

BACKGROUND

History of Project

This project began with interest from the Chesapeake Bay Commission and the goal of nutrient removal for Chesapeake Bay Tributary Strategy of 2010. After a presentation to the Commission on the alternative uses of animal manure, Bill Achor, formerly of Wenger's Feed Mill, was contacted by the Chesapeake Bay Commission and informed that the Borough of Duncannon was interested in building an alternative energy plant to provide their 900 residents with a stable electric supply. Communications began with the Chairman of the Utilities Committee on the utilization of organic residuals and the emerging policy that could enable entities to capitalize on multiple environmental benefits. Cursory conversations with technology contacts and consultants proved that existing technology was available. It was determined that public funding could be made available for a feasibility study/gap analysis.

LandStudies, Inc. became involved in the project through a contact with Wenger's Feed Mill. Early 2007, LandStudies was awarded the contract for Phase I. Also at that time, Bill Achor joined the LandStudies staff and was able to maintain close contact with the Borough of Duncannon through the various funding options for Phase I which in turn progressed into Phase II.

Phases of Project

LandStudies, Inc. envisioned a "Manure to Energy" plant being developed in a four-phase process. The first phase included searching for feasibility study funding. This phase was completed with initial funding of $10,000.00 from the Borough of Duncannon. Phase I of the project included the identification of a funding process, initiation of the funding application with a scope of work for the feasibility, and to secure funding for Phase II.

Phase I secured $130,000.00 in funding from the Chesapeake Bay Commission for the Phase II feasibility. This money was used to examine the broad-scale feasibility of a poultry litter to energy plant in the Chesapeake Bay Watershed and more specifically in the Borough of Duncannon. LandStudies, Inc. partnered with Five Winds International, an environmental management consultant, which would give critical environmental, social, and financial cost/benefit analysis for the project.

Phase II was comprised of five tasks including: identification of stakeholders, collaboration with Five Winds International on the Life Cycle Assessment, identification of potential credit trading, evaluation of technology, and recommendations for future funding. This phase was projected for an eight-month deadline and completion by January 2008.

Phase III would include the selection of a specific site and the process of land development. Site selection and land development will take into account parameters such as proximity to manure supply, access to water, proximity of a steam host, transportation logistics, air emissions testing, applicable regulations (zoning, subdivision and land development, etc.), land acquisition, etc. Some of this information was examined in a very general way during Phase II. Phase III will presumably be funded by one of the contacts from Phase II.

The actual building of the plant is anticipated for Phase IV. During that aspect of the project, all site development issues will have been finalized as well as the necessary permitting and regulatory action. Funding for the construction phase may occur through the financing of the entity wanting the power, in this case the Borough of Duncannon. It may also be financed through a power company that is looking for renewable energy to help them meet their requirements under Act 213, the Alternative Energy Portfolio Standards (AEPS). The search for the construction funding depends on the needs and wants of the entity pursuing the plant.

TIMING

The overall timing of this project occurs simultaneously with the implementation of four major strategies in Pennsylvania. These strategies include the Chesapeake Bay Strategy of 2010, Act 213, Governor Rendell's Energy Independence Strategy, and the Deregulation of Electricity in 2010. The combination of these factors provides an active climate for innovation and change.

Chesapeake Bay Strategy

Pennsylvania provides over half of the total water supply to the Chesapeake Bay. For this reason, Pennsylvania is an essential partner in achieving the necessary nutrient and sediment reduction mandated by the Chesapeake Bay Tributary Strategy. Pennsylvania has been a signatory since the original 1983 agreement and has worked diligently at implementing programs to improve water quality. To meet new water quality goals established by the most recent version of the agreement (2000), Pennsylvania will need to reduce nitrogen by an additional 37 million pounds per year, phosphorus by an additional 1.1 million pounds per year, and sediment by an additional 116,000 tons per year. There are twelve major initiatives which are to be implemented to help Pennsylvania achieve these significant goals. See Table 1.

Table 1. Chesapeake Bay Strategy Initiatives for Pennsylvania.

• Limited wastewater & Industrial discharges	• Upgrading sewer & Water Infrastructure
• Securing conservation easements for riparian buffers	• Preserving agriculture, communities, and rural environments
• Accelerating dam removal & building fish passageways	• Expanding the Conservation Reserve Enhancement Program (CREP)
• Increasing forested buffers & wetlands	• Supporting CBF's Riparian Forest Buffer Program
• Promoting Manure-to-Energy programs	• Leading the way in nutrient trading
• Supporting Growing Greener II	• Enhancing stormwater management

As shown above, supporting "Manure-to-Energy" projects is one of the top priorities in achieving the goals of the Chesapeake Bay. The Borough of Duncannon recognized this new priority which helped to provide justification for pursing a project of this type. Pennsylvania, as well as the other contributors to the Bay, has a vested interest to find alternative ways to deal with residuals that have caused some of the nutrient and sediment degradation to the water resource.

Electric Deregulation

The Borough of Duncannon is the current provider of electricity to their residents. They purchase electricity from the grid, and then distribute and sell it to their residents. When deregulation occurs, the price of electricity could increase by as much as 70%.

By definition, deregulation is the removal of government controls from an industry to allow for a free and efficient market place. Pennsylvania's Restructuring Act of 1996 initiated the movement toward an open market for electric generators. By 1999, approximately two-thirds of Pennsylvanian citizens could choose their electric generators. Rates were capped at the 1997 levels until 2005. All generation rate caps will be removed by 2010.

There are many concerns associated with this process. One of those, from the side of the electric generator, is the "stranded costs". Utilities are allowed to recover the cost of the investments made to serve its existing customers. A stranded cost occurs when customers of one utility leave that utility and have power brought to them from some other supplier. This leaves the original utility with debts for plants and equipment it may no longer need and without the revenue from the ratepayers the plants were built to serve. These investments can include power generation facilities, transmission lines, nuclear plant maintenance and decommissioning costs, and a variety of conservation measures.[1]

Additionally, it is unknown what transition costs will result from deregulation. There are instances when utility companies may levy a transition charge on consumers to help recover some of their stranded costs. In most cases, utilities are only permitted to recover a portion of their stranded costs in this fashion.[2] Also, utility transition costs are calculated when determining the necessary costs to meet the requirements of the Alternative Energy Portfolio Standard (AEPS - Act 213) without actually constructing the technology. The AEPS is explained in detail later in this report.

For many locations, rate hikes were approved prior to deregulation so that consumers will not see an "all-at-once" increase in their electric bills. For example, PPL's recent PUC approved incremental rate increase allows customers to "pre-pay" the increase to avoid the all-at-once financial burden.

Alternative Energy Portfolio Standards and Energy Independence Strategy

Governor Rendell signed the Alternative Energy Portfolio Standards (Act 213) into law on November 30, 2004. Act 213 took effect on February 28, 2005. Ultimately, the goal of Act 213 is to foster economic development and encourage reliance on more diverse and environmentally friendly sources of electricity. The Alternative Energy Portfolio Standard requires utilities to

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[1] "What's a stranded cost?". *Tennessee Power Company*. January 25, 2008. http://home.earthlink.net/~tpco/stranded.html

[2] "Stranded costs, transition costs, and stranded assessments". *Energy Dictionary: Vortex Energy*. http://www.energyvortex.com/energydictionary/stranded_costs__transition_costs__stranded_assets.html

gradually increase the percentage of electricity sold to retail customers by electric distribution companies and electric generation suppliers to be derived from "alternative energy sources." These alternative energy standards also help to provide meaningful environmental and economic benefits for the citizens of Pennsylvania.

The AEPS ensure that in 15 years, 18 percent of all electricity sold in Pennsylvania comes from clean, advanced sources. Today, over 20 states have renewable energy goals. The Pennsylvania standards are broken into two tiers. Tier I requires 8 percent of electricity sold to come from traditional renewable sources such as solar photovoltaic energy, wind power, low-impact hydropower, geothermal energy, biologically derived methane gas, fuel cells, biomass energy or coal-mine methane.

Tier II requires 10 percent of Pennsylvania sold electricity to be generated from waste coal, distributed generation systems, demand-side management, large-scale hydropower, municipal solid waste, generation from pulping and wood manufacturing byproducts, and integrated combined coal gasification technology.

The Energy Independence Strategy (EIS), a Governor Rendell Initiative, helps to bolster economic incentives, grants, low interest loans, bonds, etc. The EIS will make $850 million investment that will help Pennsylvania achieve three key goals:

- Save consumers $10 billion in energy costs over the next 10 years;
- Expand Pennsylvania's energy production and energy technology sectors to create more jobs; and
- Reduce Pennsylvania's reliance on foreign fuels and increase Pennsylvania's clean energy production capacity.

The Energy Independence Strategy contains important energy conservation and green building initiatives. The strategy will leverage private-sector expertise to help Pennsylvania companies cut energy costs by using state-of-the-art conservation technology. Energy consumers at work and at home will save money because utilities will be required to invest in conservation measures before more costly additional power or power plants.[3]

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[3] *"Governor Rendell Details Pennsylvania's Energy Independence Strategy in Speech to Pittsburgh Technology Council"*. Department of Environmental Protection: Daily Update. March 2, 2007.

BIOMASS FUELS

Biomass as an Alternative Fuel

The most practical and beneficial way to implement alternative energy sources should be decided with a geographic mindset by examining regional characteristics and conditions of the available fuels. Based on available fuel types, certain regions offer different alternative energy options than others. As Pennsylvania continues to pursue alternative energy sources in an effort to reduce greenhouse gases and pollutants released into the atmosphere from the burning of fossil fuels, the potential of using biomass for fuel is finally being recognized as a viable option for generating power.

Biomass is a renewable, carbon-based organic matter. Biomass feedstocks include wood residues such as sawdust, wood chips, wood waste; agricultural residues such as animal waste, corn stover, rice hulls, sugarcane bagasse; and energy crops such as switchgrass, reed canary grass, willow, and hybrid poplar. Extensive research on using biomass feedstocks as potential fuel sources and processes that convert these fuels into power has been conducted throughout the state, nation, and global scientific community. Findings have shown that with the right combination of biomass fuel, technology, and availability, power can be generated efficiently and economically. The use of some biomass fuels is more appropriate than others based upon each fuel's properties, availability, and versatility as well as the environmental benefit of using such a fuel. For example, the use of agricultural byproducts allows for reduced fuel costs, the utilization of a waste product, greater fuel flexibility, and the use of an indigenous resource.[4]

One of the more promising biomass fuel options in Pennsylvania is the utilization of animal waste, more specifically poultry litter, to produce energy. Litter refers to the combination of poultry manure and bedding material (woodchips, sawdust) used in broiler houses.[5] At the end of 2004, there were 133,500 broilers in Pennsylvania.[6] In 2004, Pennsylvania ranked 14th in the nation for broilers produced and broiler-type chick hatch; 2nd in the nation for egg-type chick hatch; and 3rd for egg production.[7]

The Duncannon Manure to Energy Project aims to utilize poultry litter, produced at numerous broiler farms in the surrounding region, as a fuel source to generate electricity for the residents of Duncannon Borough. As proposed, a power plant equipped with a generation system able to use poultry litter will be designed and constructed at a location within or near the Borough. Duncannon Borough's desire to establish the proposed poultry litter to energy plant is an

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[4] "Utilization of Biofuels in Boilers." Program Fact Sheet. The Energy Institute. College of Earth & Mineral Sciences. Penn State University. www.energy.psu.edu

[5] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

[6] Pennsylvania Agricultural Statistics 2004-2005. Compiled by USDA's National Agricultural Statistics Service, Pennsylvania Field Office. November 2005.

[7] Ibid.

example of an innovative approach to generate power using alternative energy sources. It also stands to help reduce excessive nutrients in the Chesapeake Bay Watershed, which is consistent with the Chesapeake Bay Strategy of 2010, Act 213, Governor Rendell's Energy Independence Strategy, and the Deregulation of Electricity in 2010 as described earlier.

Why Poultry Litter?

Considering the many types of animal waste produced in Pennsylvania, one would ask, "Why use poultry litter?" Geographically, Pennsylvania, more specifically the Chesapeake Bay Watershed, is one the nation's largest producers of broilers and thus chicken litter. In other words, the state has a plentiful and renewable supply of chicken litter. Additionally, Lancaster County has been identified by the Environmental Protection Agency (EPA) amongst the top three nutrient excessive hotspots in the nation. This is a result of the high concentrations of livestock farm operations located there, especially poultry. Although the Borough of Duncannon is not located within Lancaster County, it is located within reasonable trucking distance to this large concentration of poultry manure.

Another reason poultry litter is a practical biomass fuel source is the composition of the litter. Litter composition consists of mostly carbon and water with lesser amounts of nitrogen, phosphorus and trace levels of a variety of elements including chlorine, calcium, magnesium, sodium, manganese, iron, copper, and zinc.[8] The presence of carbon allows for the conversion of the waste product to energy using a variety of technological processes as described later in this report. Poultry litter has an energy content roughly equivalent to lignite (a mediocre grade of coal) and better than green firewood.[9] Thus, chicken litter naturally contains compounds and BTU values that enable energy generation. See Table 2.

Poultry litter, specifically broiler litter, has low moisture content, which increases the efficiency of energy production and is easier to handle and transport than other wetter animal waste products. Adding to the ease of transport is the fact that the poultry litter is usually concentrated at specific locations both on the farm and regionally throughout the state. Of course, the moisture content of the manure may vary depending upon handling and storage at the farm, which is a factor that must be considered when using poultry litter as fuel source. The caloric value of poultry litter decreases with increasing moisture content.[10] There are traditional processes of material handling equipment that can minimize moisture content by using waste heat to dry the litter.

Poultry litter has an approximate BTU value ranging from 3,600 to 6,500 per pound depending on moisture content. While coal has an average BTU value of 10,000 – 15,500 per pound. Typical poultry litter has a moisture content of around 30%. For this reason, some of the

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[8] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

[9] WastePro Engineering, Inc. "Grand Lake Waste-to-Energy Study: Report and Recommendations." March 2004.

[10] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

technology consultants suggested adding wood chips to the poultry litter to help provide a more consistent BTU value. A combination of 30% wood chips and 70% chicken litter was recommended.

Table 2. Characteristics of different fuel types.[11]

	PDF*	Coal	Wood
Carbon, dry wt. %	39.5	74.0	49.7
Hydrogen, dry wt. %	4.3	5.1	5.4
Nitrogen, dry wt. %	3.9	1.6	0.2
Sulfur, dry wt. %	0.8	2.3	0.1
Ash, dry wt. %	22.9	9.1	5.3
Chlorine, dry wt. %	1.28	0.0	0.0
Oxygen, dry wt. %	27.3	7.9	39.3
Moisture, %	20-35	5.2	50
Dry HHV, Btu/lb.**	6572	13250	8800
LHV*, Btu/lb. as fired**	3600-4400	12050	3315

*Poultry Derived Fuel **High Heating Value ***Low Heating Value

NOTE: PDF values are typical of poultry litter generated throughout the Delmarva (Delaware, Maryland, Virginia) poultry producing region.

The use of poultry litter as a fuel has a smaller environmental impact or footprint than the extraction and burning of fossil fuels. No extraction of the material is necessary, which prevents any degradation to the natural landscape. Although the burning of poultry litter produces emissions of carbon dioxide, the U.S. EPA does not consider it to be a greenhouse gas emission that increases global warming. This is because burning poultry derived fuels recycles carbon that already exists in the environment instead of introducing new carbon into the environment as with the burning of fossil fuels such as coal, oil, or natural gas.[12] Carbon dioxide emissions from fossil fuels *do* potentially increase global warming because the carbon contained in coal, oil, or natural gas is normally sequestered from the environment underground until it is extracted for use as a fuel.[13] Processes that convert poultry litter to energy generate waste products, such as ash, that are manageable and can be re-used for other purposes such as commercial fertilizer. The sulfur content of poultry litter is significantly lower than fossil fuels such as coal. In addition, many studies have been performed that show a reduction in sulfur composition through the use of additives such as limestone. Although NOx emissions during energy production using poultry litter may be higher than the burning of fossil fuels, these emissions can be managed with approved traditional emission abatement equipment. Furthermore, studies have shown that the ammonia and urea-based compounds naturally occurring in poultry manure may have a NOx

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[11] Murphy, Michael. "Fluidized Bed Technology Solution to Animal Waste Disposal." Energy Products of Idaho. Presented at the Seventeenth Annual International Pittsburgh Coal Conference. September 2000.

[12] "A review of the expected air emissions for the proposed Fibroshore 40-MW power plant to be fueled with poultry litter and wood." Alternative Resources, Inc. Prepared for Maryland Environmental Services. February 2001.

[13] Ibid.

reducing effect. Urea reacts with NOx at temperatures between 1650ºF and 2100ºF to produce molecular nitrogen (N_2) and water.[14]

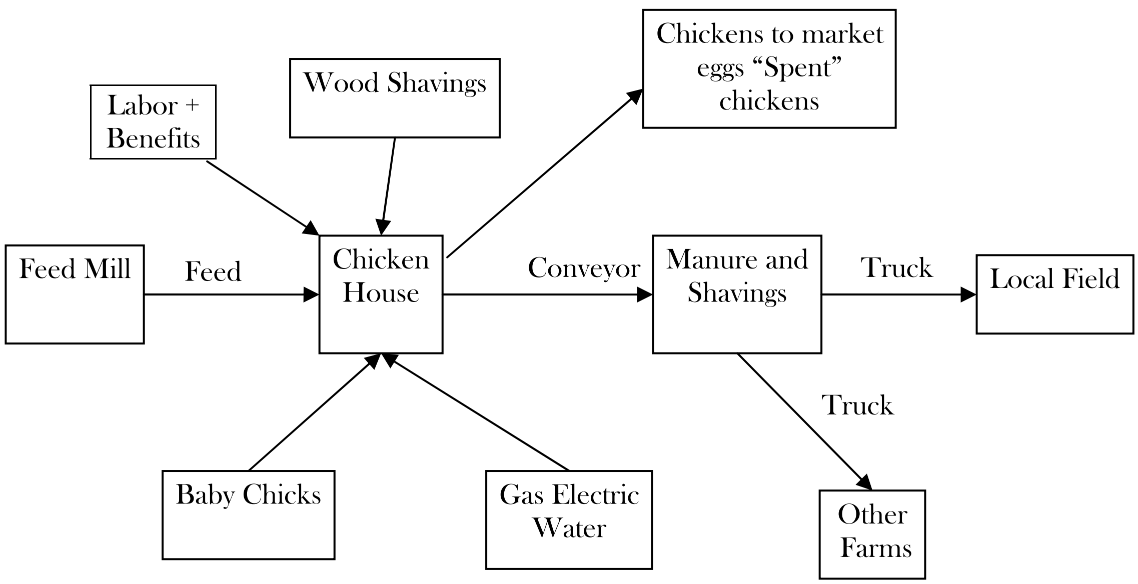
Lastly, using poultry litter as a fuel limits the volume used for land application, which helps to improve water quality in the state and, more specifically, the Chesapeake Bay Watershed. Land application of poultry manure is recognized as a major contributor to nutrient loads in the Chesapeake Bay Watershed. The excess nutrients reduce water quality as they are introduced into existing water resources through absorption or erosion. Using excess manure as a fuel would provide an alternative to land application.

[14] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

POULTRY FARMING – THE CURRENT PROCESS

Components
There are two major areas to consider in the current poultry farming process. See Figure 2. They include the chicken house or farmstead and the field. Each of these requires several inputs and results in various outputs which can have a negative or positive impact depending on the usage.

Figure 2. Poultry farming components and process.



Poultry House
Poultry houses range in structure and size throughout the poultry industry. But there is also variation across Europe, the United States, Asia and South America. For the purposes of this project, each chicken house was assumed to hold approximately 25,000 broilers. An important distinction as it applies to this project occurs between broilers and layers. Broilers are raised for meat production while layers are grown to produce eggs. The birds are housed differently as well. Broilers are grown in a house lined with wood shavings or bedding. Layers are housed in a facility with raised, mesh floors. This allows their droppings to fall to the floor which can then be scraped out with a tractor and other equipment.

When it is time to clean out the broiler house, there are two types of cleaning that may occur. The first is a complete cleanout. This means the manure that has collected on the wood shavings as well as the wood shavings are removed from the house. The second scenario is a partial clean-out or "de-caking". This process removes the surface layer or concentrated manure in the house while leaving the rest of the wood shavings or bedding.

A chicken house will traditionally go through approximately five to six groups of broilers annually. At 25,000 birds in a flock, the average chicken house in Pennsylvania produces around 125,000 to 150,000 birds a year.

Trucking

Due to agriculture regulation in Pennsylvania, farms that have over 2,000 pounds of live weight per acre (2 AU/acre) of farmland are regulated under Act 38 (Refer to *Benefits* section). Farms that are regulated under Act 38 must have a Nutrient Management Plan. Within this plan, a system is outlined on how and where the manure from the farm can or should go. Most poultry farms are located on a limited amount of land. For that reason, the manure can not be land applied on the home farm, which has been the traditional method of manure disposal.

Manure now must be trucked away from the farm to areas that are nutrient deficient. These farms are primarily composed of crops ranging from corn to soybeans. Unfortunately, it is not always convenient or cost effective to ship the manure to locations of nutrient deficiency. For that reason, a manure-to-energy plant could provide a critical alternative utilization option for excess poultry litter.

As identified in a report generated by the Chesapeake Bay Foundation, regions with concentrated poultry production operations will most likely be the most appropriate location for large, litter-to-energy facilities.[15] The close proximity to the fuel source would help to reduce the costs associated with manure transport. However, bio-security is one important issue that arises with the trucking of manure from multiple farm sites. As trucks collect the poultry litter, they must be emptied and disinfected in between each farm because transferring manure from one farm to the next can increase the risk of disease spreading.

The cost of trucking manure has been referenced several times in the report. To better understand this cost, a local family owned and operated trucking company, Jagtrux, Inc., was contacted to discuss trucking logistics and costs associated with the proposed manure to energy plant. Several important details were suggested during conversations with representatives from this company. They suggested that a special exemption to haul heavy loads might be required. Also, trucks that utilize walking floor trailers were proposed as the most efficient tool to load and unload. To maintain efficiency, they suggested that four loads of manure should be hauled in to the plant to every one load of ash and dry residuals hauled out. It would be crucial to keep the trucks moving as much as possible. To accomplish this, Jagtrux suggested dropping trailers off at the farms to have them loaded while the truck hitches up to a pre-loaded trailer to haul to the power plant. The same would be done at the power plant. A loaded trailer would be dropped off and the truck would hitch up to an empty trailer to take back to the farm. This would keep the tractor in constant movement with no "down time," thereby maintaining efficiency and productivity.

[15] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

Field

Traditionally, manure that was generated on a farm from livestock production was applied to the fields of that farm. The manure was essential to grow feed for animals and crops for humans. Keeping the manure on the farm where it was generated formed a closed loop system. Today, the agricultural industry has shifted to monoculture style farming and a closed loop system no longer exists. With increased livestock production, farms now generate more nutrients than before and an excess in nutrients (nitrogen and phosphorous) can occur.

In order to address some of the issue mentioned above, the state of Pennsylvania issued Nutrient Management Act 38. Act 38 requires all Concentrated Animal Operations (CAO) to develop, submit, and implement a nutrient management plan. A CAO is defined as any farm where the animal density exceeds 2,000 pounds per one acre of land suitable for manure application.[16] Many poultry producing facilities fall into the CAO category because they are located on small tracts of land relative to livestock density. As a result, manure is exported, in compliance with Act 38 requirements, to crop farmers who require additional nutrients as fertilizer. Currently, only 24% of available lands (crop acres) in Pennsylvania receive manure. This means that around 76% of crop acres could utilize additional manure. In order to help regulate the importation of manure, Act 49 was passed in 2004. Act 49 was designed to regulate the hauling, land-application, or brokerage of manure in Pennsylvania and to ensure that manure generated by agricultural operations is transported and applied in a safe manner.[17] However, the logistics of transporting the manure make it difficult for many large broiler farming operations to find suitable locations for their excess manure without financial burden.

It is important to remember that the application of manure to the fields is not necessarily a bad thing. But, the amount, timing, and method of application are what make manure transition from a benefit to a pollutant.

Inputs

Under the current poultry farm process, there are approximately six major inputs that are required for proper operation. They include the baby chicks, the feed, bedding, gas or electric power, and water. Each of these inputs has some nuance that requires attention when examining a project of this type.

Feed

Poultry birds are very efficient in converting nutrients to protein. In fact, they are the most efficient livestock animal in this conversion. One of the most important components in maintaining this efficiency is the density of the feed. Poultry feed is a unique blend that has been referred to as a “complete” feed because the food is designed to contain all the protein, energy, vitamins, minerals, and other nutrients necessary for proper growth, egg production, and health

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[16] SCC Nutrient Management Act Program. *Technical Manual: Section I – Identification of CAOs.* May, 2003.

[17] “Manure Hauler and Broker Program”. *Pennsylvania Department of Agriculture*. January 28, 2008 http://www.agriculture.state.pa.us/agriculture/cwp/view.asp?a=3&Q=138120

of the birds. The goal of the feeding is to offer high nutrients which allows for high growth efficiency and a reduction in excreted nutrients.

Bedding – Wood shavings and/or saw dust

Most poultry producers line their houses with bedding composed primarily of wood shavings or sawdust. Many Pennsylvania poultry producers will complete a total clean-out of the house after each flock is sent to the processing plant. This helps to prevent the spread of disease to new flocks. A total clean-out consists of the removal of all bedding and manure.

However, this can be an expensive process. One factor that could impact future bedding costs is the development of wood-waste fueled biomass plants. The competing market for the wood waste fuel materials could drive up the cost of wood residue. Because of this, many poultry growers are using the same bedding material for multiple flocks. Additionally, on the Delmarva Peninsula, poultry houses are undergoing complete cleanouts every 2-4 years.[18] If a complete cleanout does not occur, only the "cake" is removed. "Cake" refers to the clumps of manure that accumulate on top of the bedding material. Cake cleanouts produce substantially less available manure.

Based on these factors, it is critically important to make note of the typical clean-out processes of poultry producers involved in supplying manure to the proposed energy plant. These types of logistics are imperative to the long-term success of the project.

Outputs

Manure and Shavings

Currently, it is perceived that manure is not managed in an appropriate manner based on the pollution issues affecting not only the Chesapeake Bay but other areas of the country. As mentioned earlier, poultry litter is being applied to fields in place of commercial fertilizer. Commercial fertilizer costs and trucking costs associated with moving manure must be considered when competing with nutrient deficient farms for the litter. In order to maintain a steady supply of chicken litter, long-range contracts should be signed by all integrators.

An important consideration when calculating the amount of chicken litter available for the proposed manure to energy plant is the method of clean-out. As discussed earlier, not all poultry houses remove manure after each rotation of chickens. Some houses will only perform a full clean-out every 2 to 4 years while others will perform a complete clean out after each rotation of chickens. This could significantly affect the available amount of manure. This is an important issue when determining the logistics of poultry manure movement.

[18] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

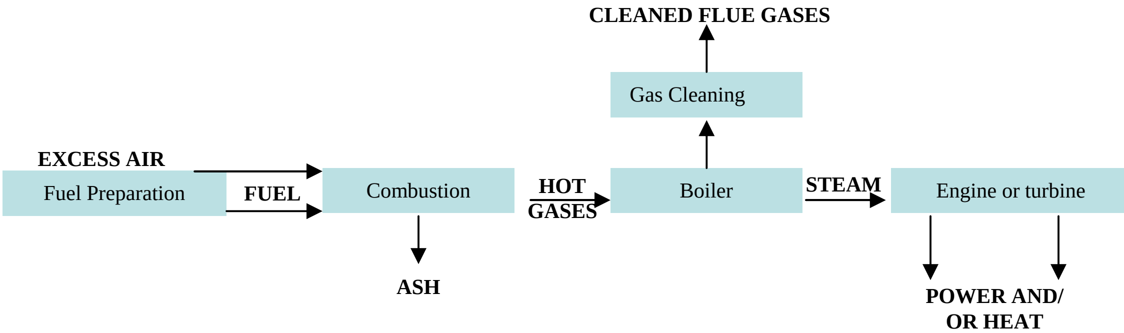
TECHNOLOGICAL PROCESSES

The following section includes brief, non-comprehensive descriptions of a few processes that convert poultry litter to energy. A full systems analysis should be performed before deciding which process is most appropriate for the proposed power plant.

Thermal (Direct) Combustion

Direct combustion is the burning of fuel with excess air, producing hot flue gases that are used to produce steam in the heat exchange area of boiler.[19] The steam is then used to produce electricity in steam turbine generators.[20] The two most common types of boilers are stoker boilers and fluidized bed boilers.[21] Direct combustion is a common and proven technology that is more versatile than many other processes in terms of the types of fuel that may be used.

Figure 3. Flow Chart of a conventional direct combustion waste to energy plant.[22]



Combustion usually takes place at temperatures as high as 3600ºF and requires either stoichiometric conditions (consuming reagents in the exact proportions required for a given reaction) or an excess amount of oxygen.[23] The main products of direct combustion are CO_2, H_20, and ash. Combusting poultry litter concentrates the nutrient contents (P and K) in the ash and results in significant volume reduction (up to 90%), making it easy to transport.[24] This nutrient rich ash may have value as a fertilizer.[25] Direct combustion systems must have clean

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[19] Flora, J. and Riahi-Nezhad, C. "Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production." University of South Carolina. August 2006.

[20] Ibid.

[21] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

[22] Australian Business Council for Sustainable Energy. "Waste to Energy: A Guide for Local Authorities." May 2005. www.bcse.org.au/docs/Publications_Reports/WasteToEnergy%20Report.pdf

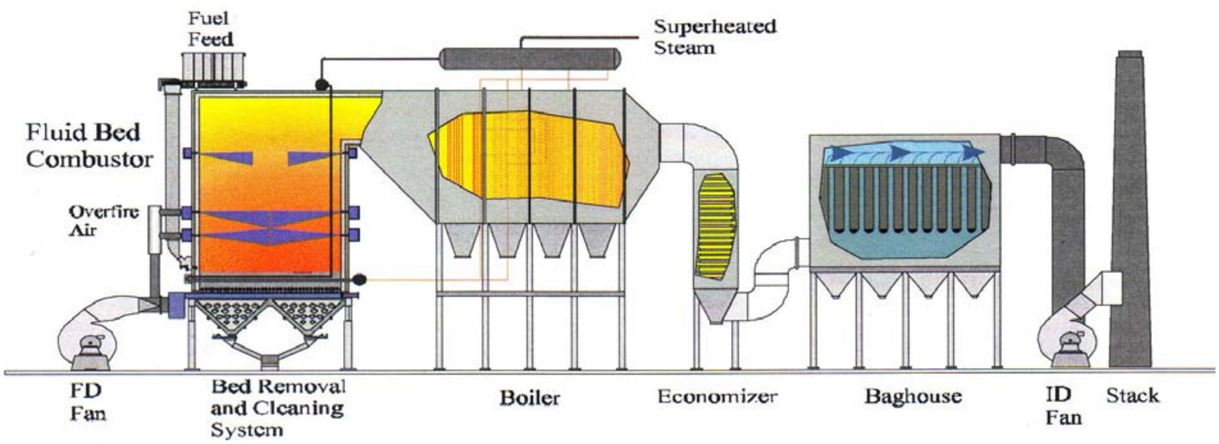
[23] Ibid.

[24] Ibid.

[25] WastePro Engineering, Inc. "Grand Lake Waste-to-Energy Study: Report and Recommendations." March 2004.

water source (low silicate content and conductivity) because particulate matter can cause slagging or build up in the steam turbines, which can decrease the efficiency of the boiler. Typical elements of a thermal combustion boiler plant include a 10,000 square-foot minimum building, a burner, a blower, a steam turbine, water treatment facility, a bag house, a storage facility, and an unloading facility.

Figure 4. Typical Power Boiler System provided by Energy Products of Idaho (EPI).[26]



Pros: Potential for a variety of biomass fuel sources (more versatile);
Economical on a large scale;
Working examples of combustion boilers are widespread;
Ash can potentially be used for commercial fertilizer;
Lower emissions than fossil fuel combustion;
Natural ammonia and urea-compounds contained in manure may reduce NOx and produce molecular nitrogen (N_2) and water;
Adds no new CO_2 to the natural carbon cycle;
Sulfur content is lower than fossil fuels, especially when limestone is added;
No nitrogen remains in the solid phase;
Destroys harmful biological components that contribute to water pollution.

Cons: Need clean water;
Need low moisture content fuel to burn more efficiently;
Waste products include air emissions and ash;
Composition of litter may vary from farm to farm;
Silica salts formed by K and Na in ash have tendency to form slag on the hot surfaces in the boiler;
Need air pollution control devices;
Potential for “Not In My Back Yard” (NIMBY) public response.

[26] Murphy, Michael. “Fluidized Bed Technology Solution to Animal Waste Disposal.” Energy Products of Idaho. Presented at the Seventeenth Annual International Pittsburgh Coal Conference. September 2000.

Figure 5. Typical combustion unit for a "hot water" system provided by Advanced Recycling Equipment (ARE).[27]

Pyrolysis

Pyrolysis is generally used to describe the production of liquid residues and charcoal.[28] More specifically, pyrolysis is the thermal degradation of organic waste and the vaporization of volatile compounds in the total absence of oxygen at temperatures typically less than 1100ºF.[29] Generally, lower temperatures and longer reaction times will allow more oil to be produced and higher temperatures and shorter reaction times create a higher proportion of gases.[30] The main products are oils (60-70%), combustible gases (10-20%), and char (10-40%). The oil produced by the pyrolysis of organic waste, composed of mainly carbohydrate, lignin, and other decomposition compounds, is unstable, acidic, corrosive, viscous, and includes some amounts of water and ash. However, this bio-oil can be further refined to be used as a diesel-like fuel. Pyrolysis bio-oil has a heating value of approximately 60% that of diesel on a volume basis. The bio-oil can be fired as a boiler fuel. The bio-oil may be produced at a different location from where it is used by using existing transportation and storage methods that are applicable to conventional liquid fuels.[31] Gases include mainly CO_2, CO, H_2, CH_4, lower concentrations of other hydrocarbon gases, and uncondensed pyrolysis oil. These gases have roughly half of the

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[27] "Biomass Energy: Providing Alternative Energy Sources." Challenger® Power Point Presentation. Advanced Recycling Equipment, Inc.

[28] Energy Products of Idaho Website. www.energyproducts.com

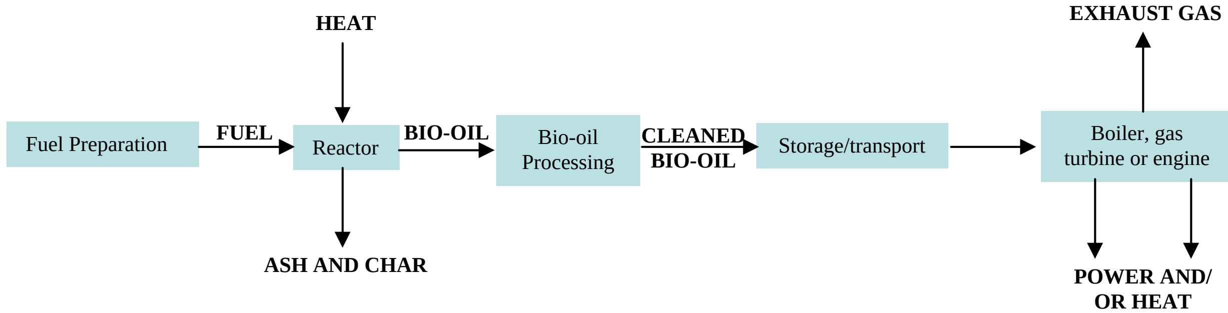
[29] Flora, J. and Riahi-Nezhad, C. "Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production." University of South Carolina. August 2006.

[30] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

[31] Australian Business Council for Sustainable Energy. "Waste to Energy: A Guide for Local Authorities." May 2005. www.bcse.org.au/docs/Publications_Reports/WasteToEnergy%20Report.pdf

caloric value as natural gas.[32] The percentage of char produced depends upon the composition of the litter and the type of system used in the pyrolysis process. Like other thermochemical processes, pyrolysis destroys microorganisms.[33]

Figure 6. Flow chart of the pyrolysis process.[34]



Pros: Lower emissions;
Char may potentially used as fertilizer ingredient;
Bio-oil can be produced at a location different from where it is used;
Products generated can be used in a variety of ways (oils, gases, char);
Process destroys microorganisms.

Cons: More expensive;
More steps in process;
Combustion of bio-oil and/or gas is still necessary to produce energy;
Potential for "NIMBY" public response.

Gasification

The difference between gasification and pyrolysis is that gasification typically refers to the production of gaseous components in an oxygen-*deficient* environment, while pyrolysis refers to the production of liquid residues and charcoal in an oxygen-*free* environment.

Gasification is the thermal decomposition of carbon-rich organic matter in an oxygen-deficient atmosphere at temperatures ranging between 1100ºF to 1800ºF. The resulting products include combustible gases (~50%), which is composed of mostly CO_2 and H_2, ash or non-converted particulate matter (~15%), and varying amounts of tars (~15%). Smaller amounts of carbon monoxide, methane, and water are also produced. The combustible gases produced are used as a fuel for boilers, internal combustion engines, or gas turbines. The quality of gas generated in a system is influenced by fuel characteristics, gasifier configuration, and the composition of air used as the gasification medium. Higher quality gas, or syngas, has roughly 30% of the caloric

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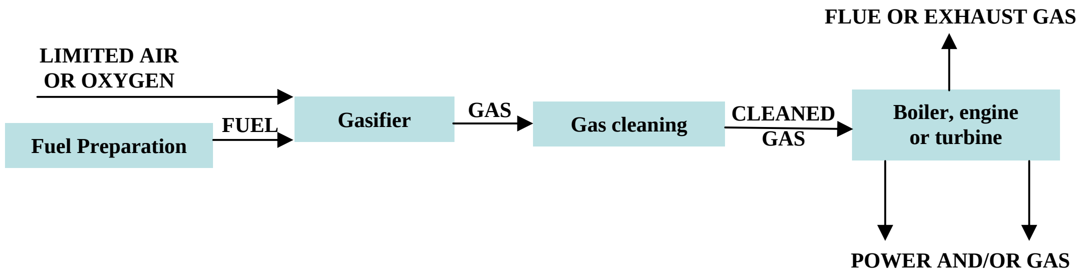
[32] Ibid.

[33] Schill, Susanne R. "Mobile Pyrolysis Plant Converts Poultry Litter to Energy." Biomass Magazine. November 2007.

[34] Australian Business Council for Sustainable Energy. "Waste to Energy: A Guide for Local Authorities." May 2005. www.bcse.org.au/docs/Publications_Reports/WasteToEnergy%20Report.pdf

value of natural gas.[35] The lower temperatures and limited oxygen supply associated with gasification lowers NOx emissions as compared to direct combustion by allowing nitrogen present in the manure to form ammonia.[36] Accumulated ash and tar must be removed before the gas is used in a boiler, engine, or turbine.[37] Gasifiers are typically used for retrofitting existing systems. Gasification systems could probably be used in nearly every application in which natural gas, oil, or pulverized coal is currently being used.[38]

Figure 7. Flow chart of the gasification process.[39]



Typically, gasification is recognized as a cleaner process than direct combustion because the byproducts are efficiently separated during the process, which allows for more effective emission control. However, based on conversations with representatives from within the technological community, some tend to disagree. Advancements in the clean-up of gas to turn gas turbines are not developed enough for commercial application. Also, to create power, a combustion process must take place. Many times, the process of gasification is used in combination with pyrolysis and combustion as described below.[40]

<u>Example of how pyrolysis, combustion, and gasification are used in combination[41]:</u>

Step #1: Pyrolysis – vaporization of volatile compounds at temperatures < 1100ºF to produce char

Step #2: Char and volatile products are combusted with oxygen to form carbon monoxide and carbon dioxide, which generates heat for gasification

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[35] Ibid.

[36] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

[37] Australian Business Council for Sustainable Energy. "Waste to Energy: A Guide for Local Authorities." May 2005. www.bcse.org.au/docs/Publications_Reports/WasteToEnergy%20Report.pdf

[38] Energy Products of Idaho Website. www.energyproducts.com

[39] Australian Business Council for Sustainable Energy. "Waste to Energy: A Guide for Local Authorities." May 2005. www.bcse.org.au/docs/Publications_Reports/WasteToEnergy%20Report.pdf

[40] Flora, J. and Riahi-Nezhad, C. "Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production." University of South Carolina. August 2006.

[41] Ibid.

Step #3: Gasification – char reacts with carbon dioxide and steam to produce CO and H_2, which are the desired product gases that are directly fired in a gas turbine to generate power.

Pros: Lower NOx emissions (nitrogen in the manure forms ammonia);
Low maintenance;
Potential for a variety of fuel sources;
Potential of using ash as a fertilizer ingredient.

Cons: Involves up to 3 or more steps including combustion;
More expensive than direct combustion;
Multiple waste products including ash and tar must be disposed of;
Potential for "NIMBY" public response
Gas product cannot be stored and must be used immediately;
Limited full-scale applications in existence.

Co-Firing

Co-firing is the simultaneous combustion of a complementary fuel such as animal manure or wood waste with a base fuel, such as coal or waste coal in a coal-fired or natural gas boiler. Co-firing is usually less expensive than building a new biomass power plant because existing infrastructure can be used without significant modifications.[42] A potential benefit to burning coal with poultry litter is that the potassium (K), sodium (Na), and calcium (Ca) present in poultry litter may help to absorb excess sulfur from the coal. Therefore, a co-firing power plant would have lower sulfur emissions than a plant that burned only fossil fuels.[43] Many examples of co-firing biomass with coal exist; however, limited information exists on co-firing poultry litter with coal.[44]

Pros: Less expensive than building a new power plant;
Reduces greenhouse gas emissions by reducing the tons of coal used for energy output;
Lower fuel costs because biomass fuel is cheaper than fossil fuels;
Minimizes waste;
Reduces air pollution, water pollution, and soil contamination.

Cons: Still using fossil fuels;
Limited information on using poultry litter with coal;
Mixing with coal waste may eliminate using ash for fertilizer.[45]

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[42] Flora, J. and Riahi-Nezhad, C. "Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production." University of South Carolina. August 2006.

[43] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

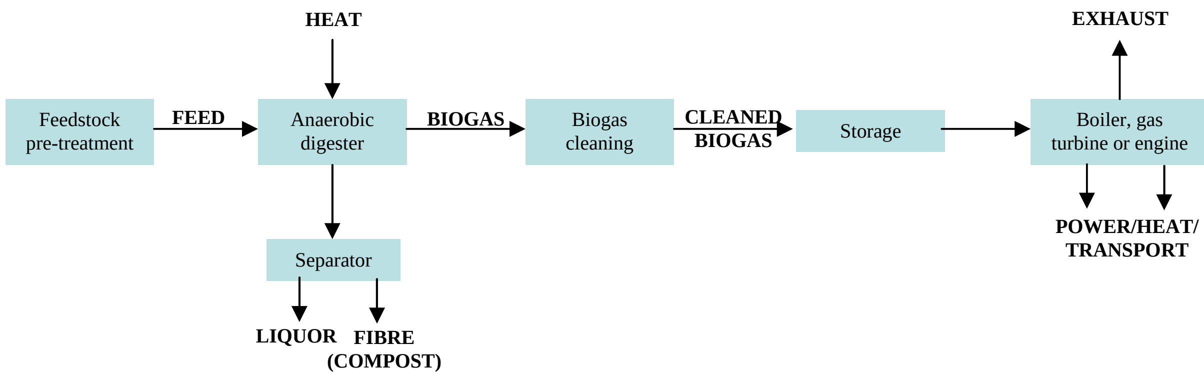
[44] Flora, J. and Riahi-Nezhad, C. "Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production." University of South Carolina. August 2006

[45] WastePro Engineering, Inc. "Grand Lake Waste-to-Energy Study: Report and Recommendations." March 2004.

Anaerobic Digestion

Anaerobic digestion is a biochemical process where microorganisms convert organic materials to a combustible bio-gas composed of methane (~55-75%), carbon dioxide (~25-45%), and other organic compounds in the absence of oxygen.[46] Anaerobic digestion systems consist of large fermentation tanks with mechanical mixing, heating, and gas collection. A significant amount of water needs to be added to the poultry litter for anaerobic digestion to occur. For this reason, this process is perhaps better suited to layer manure or other animal wastes that have higher moisture content. Anaerobic digestion can be applied using a variety of organic materials, not just manure.[47] The efficiency of anaerobic digestion is influenced by factors such as the quality of manure, the retention time in the digester, and the temperature of the digester.[48]

Figure 8. Flow chart of the anaerobic digestion process.[49]



3 Steps in Anaerobic Digestion[50]:

1. Hydrolysis (liquefaction) of animal manure by bacteria into soluble organic compounds;
2. Acetogenesis (acid production) – the conversion of decomposed matter to organic acids by volatile fatty acid formers;
3. Methanogenesis (biogas production) – conversion of organic acids to methane and carbon dioxide gas.

Pros: Can be applied for any fuel composed of organic materials - not just limited to manure.

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[46] Australian Business Council for Sustainable Energy. "Waste to Energy: A Guide for Local Authorities." May 2005. www.bcse.org.au/docs/Publications_Reports/WasteToEnergy%20Report.pdf

[47] Flora, J. and Riahi-Nezhad, C. "Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production." University of South Carolina. August 2006.

[48] Ibid.

[49] Australian Business Council for Sustainable Energy. "Waste to Energy: A Guide for Local Authorities." May 2005. www.bcse.org.au/docs/Publications_Reports/WasteToEnergy%20Report.pdf

[50] Flora, J. and Riahi-Nezhad, C. "Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production." University of South Carolina. August 2006.

Cons: Must utilize manure soon after production (less than 3 months) to prevent loss of methane-producing potential;
More expensive process;
Limited studies on capital costs of equipment specific to poultry manure;
Significant amounts of water must be added to litter;
Waste products include wet sludge high in phosphate, which will not help in reducing phosphate nutrients during land application;
More maintenance and upkeep;
Longer start up period;
Potential for “NIMBY” public response;
Biogas is not easy to store.

THE POWER PLANT

The concept of a power plant using poultry litter as fuel is not a new idea. The first poultry litter to energy power plant, which is operated by Energy Power Resources, Ltd (formerly FibroWatt, LLC), began operations in Scotland in 1993. This plant uses approximately 140,000 tons of chicken litter annually and generates 12.7 MW of electricity through combustion. Since then, the company has successfully implemented two more poultry litter to energy combustion plants in Great Britain: a 13.5 MW plant in Glanford, UK and a 38.5 MW plant in Thetford, UK.[51] In the United States, FibroWatt has recently opened the Fibrominn plant in Benson, Minnesota within the center of one of the country's largest turkey farming regions. This is the first operational poultry litter-fueled power plant in the United States. Using similar processes as the plants in Great Britain, Fibrominn uses more than 500,000 tons of turkey litter as well as other biomass annually and generates approximately 55 MW of electricity, which is enough to provide power to 40,000 homes.[52] FibroWatt has also proposed a similar plant called Fibroshore that would generate 40 MW of electricity and use approximately 300,000 tons of poultry litter and 100,000 tons of residual wood waste annually on the Delmarva Peninsula in Maryland, which is within a large broiler chicken producing region.[53] Studies are still being conducted to prove the economic viability of implementing such a plant. There is some question as to whether a plant of this size will have a sufficient amount of poultry litter available in the region possibly due to competition. A large scale poultry litter pelletization operation, known as Perdue AgriRecycle, is located nearby and relies on the same source of poultry litter.[54] FibroWatt has similar projects under development in Mississippi, North Carolina, and Arkansas.[55] In Georgia, a company called Earth Resources, Inc. is currently pursuing the construction of a 20 MW gasification power plant facility that will use chicken litter mixed with woody biomass as fuel. In addition to those mentioned above, numerous smaller-scale poultry litter to energy projects have either been proposed or are in research and development stages throughout the United States.

Many factors must be examined when developing the logistics of a manure to energy power plant. Besides the identification of a consistent fuel supply, the most important factors include location of the plant, the desired output of the plant, and the technological process to be implemented at the plant. At this time, the location and technology for the Duncannon plant have not been determined. Based upon the technological processes described earlier, it is probably safe to assume that the most appropriate technology for utilizing broiler litter is direct

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[51] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

[52] Fibrowatt, LLC Website. www.fibrowattusa.com.

[53] "A review of the expected air emissions for the proposed Fibroshore 40-MW power plant to be fueled with poultry litter and wood." Alternative Resources, Inc. Prepared for Maryland Environmental Services. February 2001.

[54] Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

[55] Fibrowatt, LLC Website. www.fibrowattusa.com.

combustion or a combination of gasification with combustion. It is known that Duncannon Borough would like the proposed power plant to generate a minimum of 2 MW of electricity. However, it may prove more economical to generate more than 2MW. Other factors to consider include the components and layout of the proposed plant, the anticipated emissions and residual waste products, emissions control methods, and air permitting. Due to the fact that many details about the Duncannon plant remain unknown, only general descriptions of these factors are presented below.

Location

As discussed earlier, the location of the power plant must be within a reasonable radius of a consistent fuel source supply in order for the plant to function as efficiently and economically as possible by limiting transportation costs. The specific location should be close to major roads and must have sufficient access for trucks entering and leaving the plant. The location should have land of adequate size to accommodate all necessary components of a power plant. Accommodations include all standard infrastructure requirements for land development such as a water source, sewage, etc. If it is decided that the plant will also provide combined heat and power capabilities using excess steam, the location should be within an appropriate distance of a viable steam host. Suitable steam hosts are typically large facilities, such as hospitals, manufacturing operations, prisons, universities, etc., that need to maintain uniform heating and cooling throughout the year. Using excess steam to provide combined heat and power would allow a power plant of any kind to be significantly more economical. The steam, which would normally be wasted, could be sold to a potential steam host at better prices than fossil fuels which typically provide combined heat and power.

Technology

As discussed earlier, several proven technological processes exist that could use poultry litter as a fuel. These technologies vary in cost, efficiency, and environmental benefits. The pros and cons of each technology should be examined closely to determine which process would provide the best option for Duncannon Borough. Considering that the desired fuel source is poultry litter (specifically broiler litter), the most likely option would be the implementation of either a direct combustion system or a gasification system. For the most part, the technological processes that apply to poultry derived fuel involve some degree of combustion. Ideally, the chosen technology should be versatile in terms of the type and composition of fuel that may be used. It would be beneficial to have a system that can burn poultry litter with has varying moisture content or even other biomass fuels if an unforeseen shortage of poultry litter may occur. Some backup biomass fuels may include wood waste, horse manure, and switchgrass. Research indicates that in all practicality, the fuel composition should be a combination of mostly poultry litter and another type of biomass fuel such as wood waste. Wood waste is a suitable choice because it is generally widely available, burns efficiently due to a high BTU value, and has relatively low emissions. Horse manure is similar in BTU value, composition, and moisture content as poultry derived fuel, but is typically less available throughout Pennsylvania. However, recent conversations with horse track operations have indicated that this industry is interested in alternative manure disposal methods. Most combustion or gasification chambers could even burn coal or coal waste if necessary without drastic modifications to the systems, however using this fuel would support the extraction and burning of fossil fuels, create higher SO_2 emissions, and could cause residue build up on equipment.

Components and Layout
The specific design and layout of a manure to energy plant would depend on the type of technology used. However, a typical facility would include a litter accumulation shelter, a combustion system, an energy-capture or transformation system, a recovered ash storage area, and an air pollution control system.[56] The storage facilities must be of sufficient size to accommodate the unloaded daily supply of fuel as well as maintain a constant supply of backup fuel. This is in case of a potential disruption to the transport of fuel to the plant. In order to minimize odor leaving the plant, negative pressure should be maintained in the storage facilities. The size or footprint of a power plant that uses biomass fuel does not vary dramatically in relation to energy output. In other words, a 5 MW plant would require similar infrastructure as a 20 MW plant. Similarly, the operations and maintenance, including staff, for a 5 MW plant would be the same as 20 MW plant.

Figure 9. Typical Advanced Recycling Equipment (ARE) combustion facility with silo storage.[57]

The following narrative, provided by WastePro Engineering, Inc., is a general description of the anticipated components for a manure to energy power plant that uses direct combustion similar to what would be proposed within or near Duncannon Borough. WastePro Engineering specializes in the consulting and designing of biomass to energy technology.

Energy Recovery from Agricultural Wastes
The project envisioned for Duncannon Borough would bring agricultural waste, specifically poultry litter and wood chips, to a facility where it would be burned for the production of electricity and/or steam. Other similar materials could be used at some point with modest modifications, mostly to the feed storage building. The size of the specific equipment discussed

[56] WastePro Engineering, Inc. "Grand Lake Waste-to-Energy Study: Report and Recommendations." March 2004.

[57] "Biomass Energy: Providing Alternative Energy Sources." Challenger® Power Point Presentation. Advanced Recycling Equipment, Inc.

will be a function of the economic design of this unit, which has not yet been determined. The equipment subsystems, as laid out in Figure 10, will consist of:

- Feed Mixing & Storage
- Combustor
- Boiler & Economizer
- Baghouse & ID Fan
- Turbine
- Cooling Tower

Each subsystem will be coordinated with the overall design to maximize efficiency and minimize both space requirements and emissions from the unit.

Feed Mixing & Storage

A paved, roofed space will be erected to provide short-term storage for fuel feedstocks. The roof will keep the materials dry and will minimize wind-borne dusting from the piled materials. Paving will be designed to allow front-end loader movement of the piled materials to a set of feed screws and hoppers. The paving will prevent stormwater run-on and -off from the piles. The feed screws will deliver the mixed fuel materials to the combustor. A forced draft fan will deliver combustion air to the combustor, taking suction from selected locations in the feed building to minimize odors.

Combustor

A fixed-hearth style burner or equivalent will be designed to burn the fuels. The hearth will be equipped with "underfire" air, which allows for safe combustion of the organic components, and provides some motive force to move the unburned, inert residues to a cooling screw by which they are removed from the combustion chamber. These solid residuals are high in phosphorous and may be valuable as a fertilizer component. The larger solids removed here plus the finer solids collected in downstream equipment will be mixed and stored in a hopper for sale. The combustion process will be controlled by speed controls on both the feed screws and the combustion air fan. Critical temperatures will be monitored to ensure optimal combustion.

Boiler & Economizer

Hot gases from the combustor will flow to a boiler, which cools the gases while producing medium-pressure steam. Feed water to the boiler will flow to an economizer at the boiler exit, thus preheating the water to increase steam output and further cool the gases. This will maximize the energy efficiency of the system.

Baghouse & ID Fan

A fabric filter will capture residuals from the cooled gas stream, maximizing residual solids recovery and minimizing particulate matter (PM) emissions. Downstream of that unit, an induced draft fan will pull gases through the system and deliver them up a stack. That stack will be the primary emissions point for the unit. It will be equipped with access and nozzles for testing of the emissions as required. Immediately upstream of the baghouse, the duct will be widened to allow for injection of alkali (soda ash), in order to capture acid gases (primarily hydrochloric acid (HCl)) that would otherwise be emitted up the stack. Further process review and design could mandate that alternative controls (i.e., wet scrubber or spray dry absorber) be installed instead of dry sorbent injection to ensure that the collected baghouse dust remains of a quality sufficient to recover it into fertilizer.

Turbine

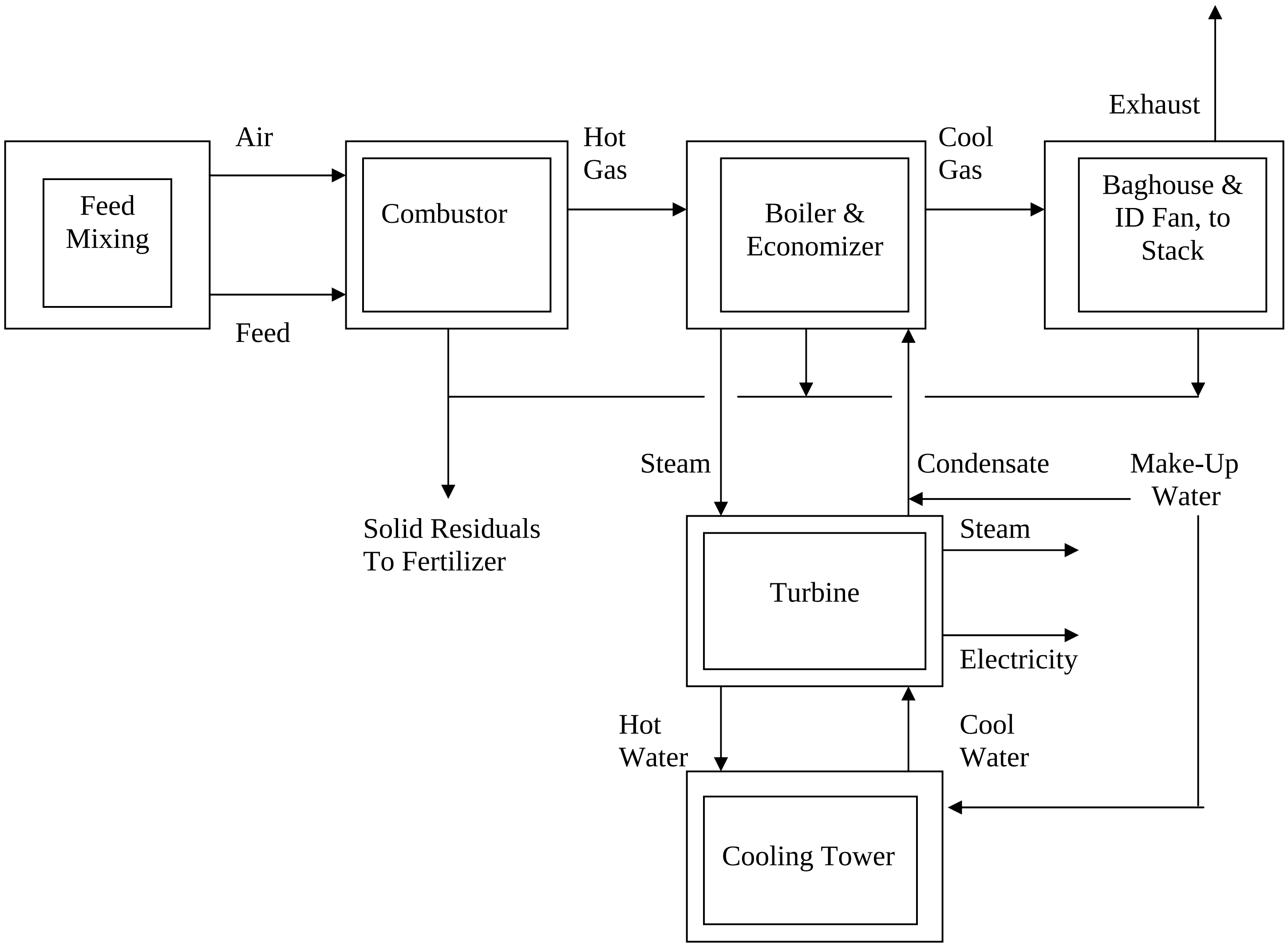
A steam-driven turbine will spin a generator, producing electricity. The turbine design will include an "extraction" port for the removal of low-pressure steam, and a condenser for complete conversion of the steam produced to electricity. Condensate from that portion of the turbine will be returned to the boiler. Boiler feed water make-up will be processed and added to replace any water lost to steam consumers and by other losses. This system design could vary the most depending on location. The best economics will develop at a site where low-pressure steam can be utilized by another facility, which in turn will change power output and water/condensate flows.

Cooling Tower

Cold water circulating to the turbine condenser maintains vacuum at this point, maximizing power output. The heated water will be cooled in a conventional cooling tower, a secondary emissions source.

-Narrative provided by WastePro Engineering, Inc. – December 2007.

Figure 10. Process Flowsheet.
Provided by WastePro Engineering, Inc.



Emissions and Residual Waste Products

Waste products will vary depending on the type of technology implemented. As with any fuel combustion, air pollutant emissions generated by a power plant that uses poultry litter as a fuel correlate to the composition of the fuel itself. The actual composition of the poultry litter may vary depending upon the region from where it is produced and what the birds are fed.[58] In any case, a manure to energy plant would produce some degree of air pollutant emissions including particulate matter, carbon monoxide, nitrogen oxide, and sulfur dioxide. Particulate matter would include trace levels of heavy metals, which are present in poultry derived fuels as well as any biomass or fossil fuels because it is ubiquitous in the natural environment.[59] Poultry derived fuels also contain sodium chloride that is present in the poultry feed, which is emitted as hydrogen chloride when combusted. Combustion of poultry derived fuel will produce small emissions of ammonia from the use of urea or ammonia as a reagent in the emissions control system.[60] Because of the regional variability of poultry litter composition, extensive sampling at potential fuel source locations should be conducted to accurately determine anticipated air emissions.

Perhaps the most significant byproduct of any combustion and gasification process is ash. After combustion, the volume of poultry litter may be reduced by up to 80% in the form of ash composed mostly of phosphorus (P) and potassium (K), which are primary plant nutrients.[61] Thus, a significant volume of ash will remain after the fuel is burned. However, this ash is easy to manage and may potentially be re-used as an ingredient in products such as manufactured fertilizer for land application. The use of manufactured fertilizers would allow for more efficient land application of nutrients than the current manure land application practices, which sometimes introduces more nutrients to the land than necessary. Studies have shown that the ash waste may be of economic value in manufactured fertilizer as well as in applications other than fertilizer. For example, ash generated by EPI systems has been used as an ingredient in cement.[62] In addition, when limestone is added to poultry derived fuel to control sulfur emission during combustion, gypsum is produced, which could be used for a variety of purposes. If used for manufactured ash products such as these, the ash may have economic value that could help offset some of the cost of a manure to energy plant. However, the exact value of poultry litter ash in the United States will not be able to be calculated until these specific ash products are produced on a commercial-scale and markets for these ash products have been developed.[63]

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[58] "A review of the expected air emissions for the proposed Fibroshore 40-MW power plant to be fueled with poultry litter and wood." Alternative Resources, Inc. Prepared for Maryland Environmental Services. February 2001.

[59] Ibid.

[60] Ibid.

[61] Bock, B.R. "Fertilizer Nutrient Value of Broiler Litter Ash." Appendix B of "Economic and technical feasibility of energy production from poultry litter and nutrient filter biomass on the lower Delmarva Peninsula." 1999.

[62] Energy Products of Idaho Website. www.energyproducts.com

[63] Bock, B.R. "Fertilizer Nutrient Value of Broiler Litter Ash." Appendix B of "Economic and technical feasibility of energy production from poultry litter and nutrient filter biomass on the lower Delmarva Peninsula." 1999.

Air Permitting

After decisions regarding the proposed plant location, output, and layout are made, air quality permits must be obtained from federal and state regulatory agencies. Obtaining required air permits is necessary for the implementation of any newly proposed power plant. Because of the limited number of manure to energy power plants proposed in the United States, one would expect that the air permitting process may require a significant amount of time and resources before approval is obtained. In the case of the proposed Duncannon plant, it is difficult to determine the actual amount of time and costs associated with the air permitting process. Based on conversations with companies that specialize in air permitting, the cost for obtaining all necessary air permits may range anywhere from $20,000.00 at the low end to $50,000.00 or greater at the high end. Table 3 compares the anticipated maximum emissions of principal air pollutant of the Fibroshore poultry litter-fueled power plant proposed in the Delmarva Region of Maryland with maximum emission limits of traditional wood and fossil fuel power plants.

The following narrative, provided by All4, Inc., is a general description of typical air permitting processes and requirements. Permitting requirements have been related to four power plant size/output options (2, 5, 7, and 10 MW) that may be proposed in Duncannon. As discussed earlier, All4 provides expertise in air quality consulting services including air permitting, modeling, monitoring, and regulatory compliance.

Plan Approval Process

The requirements of Pennsylvania's pre-construction air permitting program are found in 25 PA Code Chapter 127, Subchapter B – Plan Approval Requirements. Pursuant to §127.11, *"a person may not cause or permit the construction or modification of an air contamination source…unless the construction, modification, reactivation or installation has been approved by the Department."* Since the boiler will be considered a new air contamination source, it will be necessary to obtain a plan approval from the Pennsylvania Department of Environmental Protection (PA DEP) Bureau of Air Quality prior to commencing construction.

Table 3. Comparison of maximum emissions of principal air pollutants (Fibroshore plant versus traditional power plants).[64]

Power Plant Type	Particulate Matter (PM_{10})	Nitrogen Oxides (NOx)	Carbon Monoxide (CO)	Acid Gases (Sulfur Dioxide + Hydrogen Chloride)
Fibroshore Maryland 40 MW Power Plant, Fuel – Poultry Litter and Wood *Estimated Maximum Controlled Emission Rates*	0.02 lb/MMBtu	Range: 0.03 to 0.20 lb/MMBtu (depending on the particular control technique ultimately justified)	0.20 lb/MMBtu	0.10 lb/MMBtu
Wood Fired Boilers **(> 100 MMBtu/hr)** *US EPA National Survey of Permit Limits 1990-1999*[2]	*Range of Permit Limits:* 0.02 - 0.10 lb/MMBtu *Typical Permit Limit:* 0.02 lb/MMBtu	*Range of Permit Limits:* 0.10 - 0.30 lb/MMBtu *Typical Permit Limit:* 0.30 lb/MMBtu	*Range of Permit Limits:* 0.30 – 2.25 lb/MMBtu *Typical Permit Limit:* 0.35 lb/MMBtu	*Range of Permit Limits:* 0.016 – 0.10 lb/MMBtu *Typical Permit Limit:* 0.023 lb/MMBtu
Oil Fired Boilers, Nos. 2 and 6 Oil[2] **(>100 MMBtu/hr)** *US EPA National Survey of Permit Limits 1990-1999*[2,3]	*Range of Permit Limits:* 0.005 – 0.08 lb/MMBtu *Typical Permit Limit:* 0.03 lb/MMBtu	*Range of Permit Limits:* 0.08 – 0.4 lb/MMBtu *Typical Permit Limit:* 0.2 lb/MMBtu	*Range of Permit Limits:* 0.02 – 0.17 lb/MMBtu *Typical Permit Limit:* 0.08 lb/MMBtu	*Range of Permit Limits:* 0.05 – 0.53 lb/MMBtu *Typical Permit Limit:* 0.3 lb/MMBtu
Coal Fired Boilers **spreader stokers only** **(100 – 1,000 MMBtu/hr)** *US EPA National Survey of Permit Limits 1990-1999*[2]	*Range of Permit Limits:* 0.02 – 0.03 lb/MMBtu *Typical Permit Limit:* 0.02 lb/MMBtu	*Range of Permit Limits:* 0.20 – 0.32 lb/MMBtu *Typical Permit Limit:* 0.25 lb/MMBtu	*Range of Permit Limits:* 0.10 – 0.23 lb/MMBtu *Typical Permit Limit:* 0.20 lb/MMBtu	*Range of Permit Limits:* 0.12 – 1.2 lb/MMBtu *Typical Permit Limit:* 0.13 lb/MMBtu
1998 and 1987 National Standards (NSPS, Subpart Da)	0.1 lb/MMBtu	1.6 lb/MWh (~0.15 lb/MMBtu)	No Limit	1.2 lb/MMBtu

[1] Averaging times for the various emission limits in this table are as follows:

- Fibroshore Maryland: NO_x emission rates are 30-day and 24-hour averages, as indicated in the table.
- Fibroshore Maryland: CO is a 24-hour average; PM is a 1-hour average. "Acid Gases" are a nominal 24-hour average, comprised of SO_2 (24 hour average) plus HCl (1 hour average).
- Wood Boilers, Oil Boilers, and Coal Boilers: The US EPA national survey information does not furnish the averaging times for the indicated permit limits.
- Coal Boilers – National Emission Standards (NSPS, Subpart Da) for NOx (1998) and for SO_2 and PM (1987): the averaging time for NOx and SO_2 is 30 days. The averaging time for PM is 1 hour.

[2] US EPA maintains an ongoing compilation of recent permit limits that represent determinations of Best Available Control Technology and Lowest Achievable Emission Rate, and maintains this information in a database referred to as US EPA's "BACT/LAER Clearinghouse."

[3] The US EPA national survey presents combined, not separate emissions information for fueling with No. 2 (distillate) oil and for fueling with No. 6 (residual) oil.

[64] "A review of the expected air emissions for the proposed Fibroshore 40-MW power plant to be fueled with poultry litter and wood." Alternative Resources, Inc. Prepared for Maryland Environmental Services. February 2001.

A plan approval application must be prepared and submitted to the PA DEP for review and approval. A plan approval application generally includes the following components:

- Project Description – a general overview of the project and a technical description of boiler and associated equipment.
- Emissions Inventory – information related to emissions associated with the use of biomass fuel (poultry litter and wood) in the boiler and emissions associated with fuel and ash handling operations.
- Identification of Applicable Requirements – a summary of Federal and State air quality regulations potentially applicable to the proposed project. This section will also include documentation of the applicability or non-applicability of major new source review (NSR).[65]
- Best Available Technology (BAT) [66]– a summary and demonstration of BAT for the boiler and ancillary equipment.
- Appendices – Requisite plan approval application forms, copies of municipal notification letters, emissions calculations and any additional documentation to support the plan approval application.

The level of effort that will be associated with preparing a plan approval application and obtaining a plan approval will depend upon the magnitude of the emissions from the facility. The magnitude of emissions will be influenced by the design of the combustion unit, the types of fuels fired, the maximum fuel firing capacity, and the level of emissions control associated with the facility. The facility's status as a major or minor source will also influence the complexity, schedule, and cost associated with obtaining a plan approval.

The facility's potential to emit regulated air pollutants will determine whether it is a "major source" of emissions under several regulatory programs. Regulated air pollutants[67] are broadly defined by the United States Environmental Protection Agency (U.S. EPA). From a construction permitting standpoint, the pollutants of primary concern are the criteria[68] pollutants which are particulate matter (PM), ground-level ozone (regulated by precursor pollutants – see below), carbon monoxide (CO), sulfur oxides (SO_2), nitrogen oxides (NO_X), and lead (Pb). Particulate matter is regulated as both fine particulate matter ($PM_{2.5}$) and coarse particulate matter (PM_{10}). Ground level ozone is formed in the lower levels of the atmosphere by a series of chemical reactions involving volatile organic compounds (VOC) and NO_X in the presence of sunlight and emissions of these "precursors" are regulated by U.S. EPA to address ozone pollution.

[65] The NSR permitting program was established by Congress in 1977 as part of the Clean Air Act (CAA) amendments. Permits obtained under NSR specify what construction is allowed, what emission limits must be met, and how the emissions source must be operated.

[66] *Best available technology* - Equipment, devices, methods or techniques as determined by the Department which will prevent, reduce or control emissions of air contaminants to the maximum degree possible and which are available or may be made available.

[67] See 40 CFR Part 70, § 70.2 – Definitions

[68] U.S. EPA refers to these pollutants as "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels.

The status of a Duncannon facility as a major source could vary under different air permitting rules. Therefore, one of the first steps in the air permitting process will be to confirm the facility's status as a major or minor source under the Federal and State attainment and non-attainment new source review (NSR) permitting provisions. The PA DEP administers both regulatory programs within Pennsylvania. The proposed facility will be located in an area that is considered in attainment with the National Ambient Air Quality Standards[69] (NAAQS) area for all of the criteria air pollutants. In attainment means that the U.S. EPA has determined that ambient levels of criteria pollutants are less than the allowable levels specified by the NAAQS. However, Pennsylvania is located within the Northeast Ozone Transport Region[70] (OTR) and all areas of the state are managed as ozone non-attainment areas. In ozone non-attainment areas, emissions of ozone precursors (NO_X and VOC) are subject to more stringent permitting requirements. Therefore, the applicability of the attainment and non-attainment major NSR permitting rules must be considered at the beginning of the project.

A complete evaluation of the emissions anticipated from the facility has not yet been completed. However, using available emissions factors and a defined level of pollution abatement, the 7 MW and 10 MW options could trigger NSR permitting requirements. Brief summaries of major NSR permitting issues for attainment and non-attainment areas are presented in the following subsections.

Attainment Area Provisions

The major NSR provisions that apply in attainment areas are the Federal regulations governing the Prevention of Significant Deterioration[71] (PSD) found at 40 CFR 52.21. Pennsylvania has been granted the authority to administer the PSD rules. For the PSD rules to apply, the facility must qualify as a major stationary source.[72] For the proposed Duncannon facility to be considered major, it must have the potential to emit[73] 250 tons per year (TPY) or more of any regulated pollutant. If the facility is determined to be a minor source under PSD, then the PSD rules will not apply.
In the event that PSD is determined to be applicable for any specific pollutant, the regulations require that, in order to be permitted, the source must demonstrate that:

- Best Available Control Technology[74] (BACT) has been applied for the PSD significant pollutant,
- The project will not cause or contribute to an exceedance of the National NAAQS or the PSD increments[75], and

[69] See 40 CFR Part 50

[70] The Northeast Ozone Transport Commission was established in Section 184 of the Clean Air Act (CAA) and includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and the Consolidated Metropolitan Statistical Area that includes the District of Columbia.

[71] See 25 PA Code Chapter 127, Subchapter D

[72] See 40 CFR Part 52, §52.21(b)(1)

[73] See 40 CFR Part 52, §52.21(b)(4)

[74] See 40 CFR Part 52, §52.21(b)(12)

[75] See 40 CFR Part 52, §52.21(c)

- The project will not result in other adverse impacts on vegetation, growth, visibility, etc.

Preparation of a permit application that addresses the PSD requirements can be a substantial undertaking, particularly if a complex dispersion modeling effort is required in order to demonstrate compliance with the NAAQS and PSD increments. In addition, PA DEP review time for such applications can be lengthy. The ability to avoid PSD applicability to the project, if justifiable, can simplify the permitting process.

Non-attainment Area Provisions

Although Duncannon is located in an attainment area for the criteria pollutants, the entire state of Pennsylvania is part of the OTR. Therefore, the facility is potentially subject to the Pennsylvania non-attainment new source review (NNSR) permitting requirements.[76] For these rules to apply, the proposed facility must qualify as either a major NO_X emitting facility or a major VOC emitting facility. For a facility located in the OTR to meet the definition of a major NO_X emitting facility it would have to emit, or have the potential to emit, 100 TPY of NO_X. For a facility located in the ozone transport region to meet the definition of a major VOC emitting facility it would have to emit, or have the potential to emit, 50 TPY of VOC. Fugitive emissions are included when making applicability determinations under Subchapter E, per Section 127.204.

If the Subchapter E NNSR permitting rules are determined to be applicable to the project, the special permit requirements of Section 127.205 will apply. As opposed to the BACT requirement under PSD, the project would require that the Lowest Achievable Emission Rate[77] (LAER) be attained for the pollutants triggering the non-attainment provisions. In addition, if the NO_X or VOC emissions are greater than 100 or 50 TPY respectively, then the emission increases will need to be "offset." For a new facility, emissions offsets would need to be purchased by the facility. In this instance, offsets would be emission reductions of NO_X or VOC that were realized at another facility within Pennsylvania that were generated by either the shut down of a source or by over-controlling emissions. Finally, an evaluation of alternative sites, sizes, production processes, and environmental control techniques that demonstrates that the benefits outweigh any environmental and social consequences of the project must be provided.

Other Issues

In addition to the attainment and non-attainment permitting provisions described above, the facility will emit listed hazardous air pollutants (HAP) including hydrochloric acid (HCl). HAPs are regulated under Section 112 of the Federal Clean Air Act (CAA). A facility that emits 10 TPY or more of any single HAP or emits 25 TPY of any combination of HAPs is considered to be a major source of HAP and may be subject to additional permitting requirements. The U.S. EPA

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[76] See 25 PA Code Chapter 127, Subchapter E

[77] *LAER - Lowest Achievable Emission Rate:* (i) The rate of emissions based on the following, whichever is more stringent:

(A) The most stringent emission limitation which is contained in the implementation plan of a state for the class or category of source unless the owner or operator of the proposed source demonstrates that the limitations are not achievable.

(B) The most stringent emission limitation which is achieved in practice by the class or category of source.

(ii) The application of the term may not allow a new or proposed modified source to emit a pollutant in excess of the amount allowable under an applicable new source standard of performance promulgated the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Industrial/Commercial/Institutional Boilers and Process Heaters[78] in 2004, but has since vacated that standard. In the absence of the vacated standard, new major sources of HAP emissions may be subject to a "case-by case" Maximum Achievable Control Technology (MACT) determination under Section 112g of the CAA. Emissions of HAPs from the 7 and 10 MW options may be sufficient to trigger a 112g MACT review.

The 2, 5, and 7 MW options will likely be subject to 40 CFR Part 60 - Standards of Performance for New Stationary Sources (NSPS), Subpart Dc - Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units. Subpart Dc includes numerical limits for SO_2 and PM. The 10 MW option will likely be subject to 40 CFR Part 60 - Standards of Performance for New Stationary Sources, Subpart Db - Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units. Subpart Db includes numerical limits for NO_X, SO_2, and PM.

Pennsylvania regulates odor emissions from industrial facilities under 25 PA Code Chapter 123, §123.31. The facility will need to be engineered and constructed with provisions to address any potential odors associated with storing and handling agricultural wastes. Although not a requirement, the PA DEP sometimes requests that applicants provide inhalation risk assessments with non-routine or controversial projects under the authority of §127.12(a)(2) and §127.36.

Permitting Timeline
The time necessary to complete a plan approval application is dependant upon the complexity of the source being permitted and the magnitude of the emissions from the source. The magnitude of the emissions will dictate any substantive additional requirements (i.e., NSR) associated with the source as described above. A simple plan approval application will generally take approximately three months to prepare. A plan approval application for a complex project could take six months or more depending upon the regulatory triggers and program requirements.

Once the application is submitted, the PA DEP will evaluate the application for completeness. If the application is deemed complete, the PA DEP will begin their technical review. The technical review time associated with a simple plan approval application is generally 2 to 4 months, dependant upon the permit backlog. Plan approvals for simple sources will, in general, be issued within six months of the application submittal date. The six month period includes a 30-day public review period and a 45-day U.S. EPA review period, and includes newspaper and PA Bulletin publishing delays. The technical review associated with complex plan approval applications that include NSR requirements can take up to one year or more and can include one or more public hearings. Controversial projects, in general, will generate greater public interest and typically more public comments. Since PA DEP is obligated to respond to all relevant public comments, time lines for controversial projects could be extended beyond typical review times.

-Narrative provided by All4, Inc. – December 2007.

[78] See 40 CFR Part 63, Subpart DDDDD

Emissions and Other Pollution Control

As with any power plant that uses combustion and/or gasification, air emissions must be controlled to comply with Federal and State air quality regulations. The magnitude of the uncontrolled emissions will influence the level of air pollution abatement that is required. As a result of the air permitting process, emission limits will be set for most pollutants according to requirements for Pennsylvania BAT and/or BACT. For nitrogen oxides, emission limits may be set based on Pennsylvania BAT and/or LAER due to the location of Duncannon Borough is within the OTR. BACT, LAER, and even BAT often require the most recent and advanced emissions control methods. According to these requirements, particulate matter would be controlled with a fabric filter (baghouse) or an equivalent control. Carbon monoxide and other volatile organic compounds would be controlled by maintaining high combustion efficiency through good combustion practice. Sulfur dioxide (SO_2) and HCl would be controlled with a spray-dry adsorber (scrubber) in combination with filter fabric or an equivalent control. Depending upon the size of the combustor and the magnitude of the NOx emissions, NO_X emissions may need to be controlled using post-combustion control systems. Post combustion NOx control systems include Selective Noncatalytic Reduction (SNCR) of NOx with urea or ammonia injection into the furnace or Selective Catalytic Reduction (SCR) of NOx in the flue gas with an add-on control device. As discussed earlier, poultry litter naturally contains calcium and ammonia which may act as reagents to help reduce sulfur dioxide and nitrogen oxides during combustion.[79]

[79] "A review of the expected air emissions for the proposed Fibroshore 40-MW power plant to be fueled with poultry litter and wood." Alternative Resources, Inc. Prepared for Maryland Environmental Services. February 2001.

ECONOMICS OF A MANURE TO ENERGY PLANT

Due to the fact that this project is being completed to determine feasibility, the specifics necessary to provide detailed capital amounts could not be calculated. For this reason, the preliminary cost analysis conducted for the Duncannon Power Plant was completed at a very general level.

A typical cost analysis of a capital project starts with the capital investment required to achieve a particular objective. The operating costs and the overhead costs associated with the project are estimated and applied to the life of the project. An evaluation of the required financial investment, payback time frame, discounted cash flow, and eventually a return on investment (ROI), is completed. This approach is useful in the determination of risk associated with an investment.

In the case of the proposal to construct an electric power generation plant for the Borough of Duncannon, a different approach was taken. The feasibility study commissioned, as stated earlier in this report has multiple benefits, not all of them economic.

The economic benefits to the Borough and its residents are very dependant upon the projected cost of fossil fuel and thereby electricity generated by traditional means into the future. The environmental benefits are difficult to quantify economically and are viewed as driving forces for other stakeholders. Those stakeholders may in fact be willing to invest in this alternative electric generating plan regardless of the short term economic impact.

Nevertheless, an effort is made to determine how much capital is justified to be invested to develop this electric generating capacity based upon biomass fuel availability in the Central Pennsylvania area.
The assumptions behind the cost analysis are as follows:

- Sufficient chicken litter is available within a 50-mile radius of the proposed site
- The chicken litter is considered to be of zero cost FOB
- The power plant operator will incur the inbound freight costs for the chicken litter
- The freight provider will be the manure broker
- The freight provider will employee driver/operators
- The power plant site will have a “truck terminal” and cleaning station on site
- Inventories of biomass fuel will be held on site sufficient for a week
- Power plant operation will be 24 hours a day, 7 days per week
- Power plant operators will provide maintenance
- For the purpose of this evaluation there is an ability to sell excess electric power to the “grid”
- All customers of Duncannon Borough will pay the same rate for electric service
- Ash disposal will be in an appropriate landfill
    - There is potential income for the nutrients available in the ash
- Incremental costs to corn farmers will be born by the corn farmers, and therefore are not included in the economic analysis of the power plant operation
- Proposed fuel mix of 70% poultry litter and 30% wood waste
- Costs are developed for poultry litter only
- Assumption is that the delivered cost/BTU for wood chips would be similar to poultry litter.

Economic Model - Input

There are facts associated with the economic analysis of a manure to energy plant. Listed below are some of those facts and assumptions.

- Energy required by the plant to create 1 kWh
  - 9,500 BTU

- Cost of transportation
  - $600 per day for a truck (for 2 round trips per day)
  - $400 per truck load (includes $4/ton to the chicken farmer)

- Distance
  - 50 miles radius of manure collection
  - Trip per truck per day: 2 round trips

Because of the proposed combination of chicken litter and wood products, facts based on each of those fuel sources are provided in the table below. See Table 4.

Table 4. Comparison of Chicken Litter and Wood Chips/Savings.

Chicken Litter	***Wood Chips/Shavings***
• Energy required by the plant to create 1 kWh = 9,500 BTU - 4,500 BTU/lb energy in litter	• Energy required by the plant to create 1 kWh = 9,500 BTU - 9,000 BTU/lb energy in wood
• Transportation capacity for a single truck of chicken litter - 50,000 lbs	• Transportation capacity for a single truck of wood chips - 40,000 lbs (assumed)
	• Wood is "zero burden" because - currently land filled - excess from sawmills

There is a certain amount of power created by each truckload of manure. Those amounts are shown below.

BTUs/truckload
=BTU/lb for chicken litter * single truck capacity of chicken litter in lbs.
=225,000,000 BTUs/truckload

kWh/truckload
=(BTUs/truckload)/BTU required for 1 kWh
=225,000,000/9,500 BTUs
=23684.21053 kWh/truckload = 23.68421053 MWh/truckload

MW/day/truckload
=MWh/truckload/24
= 0.986842105 ~ **1 MW for 1 day for 1 truckload**

Table 5. Cost of Labor and Maintenance.

Cost	Function	
$80,000	Sup / Operator 1	
$80,000	Sup / Operator 2	
$80,000	Sup / Operator 3	
$80,000	Sup / Operator 4	
$45,000	maintenance 1	
$45,000	maintenance 2	
$45,000	maintenance 3	
$45,000	maintenance 4	
$35,000	Receiving 1	
$28,000	Receiving 2	possibly only one receiving for the 2 MW plant
$100,000	plant maintenance	this number may be revised with additional engineering study

Note: The number of workers does not depend on the size of the plant

The Table 6 shown below provides a breakdown of the different size plants currently being examined for feasibility. Based on the idea of seven years of savings, the numbers help to provide an approximation of the amount that can be used to finance a plant of this type.

Table 6. Economic breakdown based on plant size.

Desired Production (MW)	2	5	7	10
Truck loads for 1MW	1	1	1	1
# of Trucks required annually	730	1825	2555	3650
Annualized cost for truckloads	$292,000	$730,000	$1,022,000	$1,460,000
Annualized cost for labor	$563,000	$563,000	$563,000	$563,000
Other costs	$100,000	$100,000	$100,000	$100,000
Subtotal	$955,000	$1,393,000	$1,685,000	$2,123,000
10% Error Factor	$95,500.00	$139,300.00	$168,500.00	$212,300.00
Total	$1,050,500	$1,532,300	$1,853,500	$2,335,300
Blended Revenue	$0.0600	$0.0480	$0.0457	$0.0440
Cost/kWh	$0.0600	$0.0350	$0.0300	$0.0270
Savings based on market	$0.0000	$0.0130	$0.0157	$0.0170
Savings per day	$2	$1,562	$2,602	$4,162
Savings over 7 years (simple)	$4,900	$3,990,700	$6,647,900	$10,633,700

From a capital position, the "sweet spot" is around 5-7 MW or 10 MW (without steam)

The summary chart above assumes the following value of the electricity generated:

- The cost avoidance that the Borough currently pays for the purchase of electricity at $0.06/kwh is treated as “income”.

- The price the Borough can sell excess electricity to the “grid” is real income at $0.04/kwh.

- The spreadsheet uses a blended value to represent the “income” depending on how much electricity is used by the borough residents and how much of the excess is sold to the “grid”.

- The attached spreadsheet allows the reader to make the appropriate “what if” changes in the assumed costs, prices and labor rates.

Conclusions

- The savings represented over a seven year period can be used to approximate how much capital is available to be invested.

- The economic view is developed without including the potential revenue available by selling the excess steam to a local industry.

- Although there is availability of Renewable Energy Credits (RECs) or Carbon trading credits, these potential revenue streams are not of sufficient significance to make the project viable with the credits alone.

- The most financial leverage is dependant on the assumed cost of fossil fuel generated electricity into the future years.

POTENTIAL REVENUE

Renewable Energy Credits (RECs) and Carbon Credits

Options for converting the environmental benefits of biomass based power into a revenue stream include, but are not limited to:

- Green Power Marketing;
- Renewable Energy Certificates (RECs); and
- Carbon Offsets.

Green power marketing refers to selling green power at a premium to commodity power in a competitive marketplace, where multiple suppliers and service offerings exist. No further analysis was conducted on this option.

Renewable energy certificates (RECs), also known as green certificates, green tags, or tradable renewable certificates, represent the environmental attributes of the power produced from renewable energy projects and are sold separately from commodity electricity.[80] RECs can be sold in either compliance markets, created by mandatory Renewable Portfolio Standards (RPSs), or voluntary markets, where buyers are driven by "beyond compliance" factors. Prices are generally higher in compliance markets, due to constraints on supply and demand. In Pennsylvania, there is a compliance market driven by the PA Alternative Energy Portfolio Standard (AEPS), which mandates 18% alternative energy resources by 2020.[81] Trading volumes and pricing for the PA compliance market were beyond the scope of this analysis, although prices appeared to be in the range of $5 – $6 per MWh in the summer of 2007.[82]

Carbon offsets, also known are carbon credits, are emission reductions (or removal enhancements) associated with a specific activity or set of activities called a "GHG project" (Greenhouse Gas). For example, generating electricity from biomass is often considered a GHG project. The size of the offset is the difference between the "baseline" GHG emissions or removals (what would have occurred in the absence of the project) and the project GHG emissions or removals. A wide range of GHG project quantification protocols has been developed to meet the unique needs of specific markets and project types. Carbon offsets are sold in both regulated markets (e.g., Kyoto Clean Development Mechanism (CDM) projects) and voluntary markets, although there is currently no regulated market in the USA. Offsets are sold by a variety of providers including project developers, aggregator/wholesalers and retailers. Offset prices are higher in regulated markets, due to constraints on supply and demand. Voluntary offset prices vary between approximately $2 and $10 per metric tonne (1 tonne = 1.1 ton) according to recent market information.[83]

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[80] U.S. DOE, Green Power Network, www.eere.energy.gov/greenpower/markets/certificates.shtml?page=0

[81] Pennsylvania Public Utility Commission, www.puc.state.pa.us/electric/electric_alt_energy.aspx

[82] Evolution Markets, Monthly Market Update: REC Markets – August 2007.

[83] Evolution Markets, Monthly Market Update: US GHG Markets – November 2007. Ecosystem Marketplace and New Carbon Finance, *State of the Voluntary Carbon Markets 2007*. Chicago Climate Exchange, www.chicagoclimateexchange.com/market/data/summary.jsf

A preliminary financial analysis of the potential annual revenue from RECs or carbon offsets was conducted. For RECs, revenue would be $20,000 - $90,000 per year, per MW of capacity, assuming REC prices of $2 - $10 per MWh. For carbon offsets, revenue would be $13,000 - $65,000 per year, per MW of capacity, assuming offset prices of $3 - $15 per metric tonne CO_2. For offsets, only power generation was considered – no heat production (e.g., combined heat and power or CHP), upstream processes (e.g., agricultural practices, transportation) or downstream processes (e.g., waste management) were considered. The net impact of CHP, upstream and downstream processes is unknown, but would be likely to increase the value of carbon offsets (i.e., increase GHG emission reductions from the project).

Comparing RECs to carbon offsets, the REC market is more mature and transaction costs are likely to be lower because quantification and verification of RECs is simpler. However, depending on market prices for RECs and carbon offsets, pursuing the REC option may not maximize revenue, especially if CHP, upstream or downstream GHG reductions from the project are significant.

Note that although it would not be possible to generate both RECs and carbon offsets from the power production process, it may be feasible to maximize revenue by generating RECs from the power production process and generating carbon offsets from CHP, upstream and downstream processes. More detailed analysis of the markets for RECs and carbon offsets, and the technical potential for CHP, upstream and downstream carbon offsets would be required to determine the feasibility of this option.

In conclusion, the compliance REC market in Pennsylvania appears to be attractive, but additional analysis would be required to determine the most attractive option between RECs and carbon offsets. This analysis could include determining the status of poultry litter in the PA AEPS (i.e., Tier I or Tier II?), obtaining more detailed market pricing information and forecasts for RECs and carbon offsets, and examining the feasibility of generating carbon offsets from CHP, upstream, and/or downstream processes such as agricultural practices and transportation.

Nutrient Credits

<u>Nutrient Credit Basics</u>

This nutrient credits framework provides calculations for nutrient credits that could be derived from the "Manure to Energy" project utilizing poultry litter. Four scenarios for different output combustion plants are analyzed for nutrient credits. See Table 6.

Additionally, two different scenarios for sources of poultry litter were analyzed. The first source scenario was based on the poultry litter coming entirely from Lancaster County, which has nearly 40 percent of the total broiler production (source of poultry litter) within approximately 50 miles of the Borough (Table 7). The second source scenario (Table 7) bases poultry litter sources on the counties with the greatest net manure exports within the 50-mile radius (Regional Manure Management Model for the Chesapeake Bay Watershed, 2005).

Calculation of the nutrient credits for a total of eight scenarios is based on estimating nutrient loads to the Chesapeake Bay under current poultry litter use practices, estimating nutrient loads to the Bay under the nutrient practices that replace the way the poultry litter had been utilized, and estimating the nutrient loads to the Bay resulting from the use of the poultry litter in the combustion facility.

Certain assumptions were necessary when calculating the nutrient credits, and these are detailed below and in the "Nutrient Credits Appendix". Assumptions were also made regarding the combustion plant and the energy production that this plant would potentially replace, and the fate of the combustion emissions and residuals that are produced. These assumptions are also detailed below.

Nutrient Credit Calculations – The nutrient credit calculations have three basic components:

- Current use of the poultry litter and the resulting loads to the Bay (a),
- Loads to the Bay resulting from the replacement practices for the poultry litter (b),
- Loads to the Bay resulting from use of the poultry litter in the combustion facility (c).

The gross nutrient credits (lbs per year) for this project are calculated as:

$$\textit{Gross credits} = a - (b + c)$$

The following table shows the mass of poultry litter that would be required annually in four different sized combustion facilities. This mass of poultry litter would need to be reliably provided to the Borough for combustion purposes.

Table 7. Mass of poultry litter needed per year for the proposed combustion facility.

Combustion Plant Size (MW)	Poultry Litter Needed (tons/year)
2	12,775
5	31,938
7	44,713
10	63,875

Poultry Litter Sources

The first four nutrient credit scenarios consider the mass of poultry litter, shown in Table 6, being exported to the Duncannon combustion facility from Lancaster County. As discussed previously, nearly 40 percent of the broiler production within 50 miles of the Borough occurs in Lancaster County. In the Pennsylvania portion of the Chesapeake Bay watershed, Lancaster County is the highest net manure exporter. (Regional Manure Management Model for the Chesapeake Bay Watershed, 2005).

As shown in Table 8, there are 51,500,000 broilers in Lancaster County. Assuming about 25,000 broilers per chicken house, six cleanouts of the poultry litter per year in each chicken house, and about 100 tons of litter per cleanout, the 10 MW Duncannon combustion facility option would utilize about 30 percent of the total poultry litter production of Lancaster County per year.

The second set of four nutrient credit scenarios consider the mass of poultry litter coming proportionally from those counties within a 50-mile radius of Duncannon that have the most manure to export. Inter-county manure export and import information for manure was taken from the Regional Manure Management Model for the Chesapeake Bay Watershed (2005), and only those counties that have a net export of manure were considered for this second set of credit scenarios. The number of broilers and the distance from the Borough were then considered in qualitatively developing the source percentages of poultry litter from counties within a 50-mile radius (Table 7). This approach was developed because it is recognized that a reliable source of poultry litter needs to be provided to the combustion facility, so counties with a high net export of manure and a large number of broilers would provide a higher reliability as a source over the long term. It was also recognized that there could be an advantage in diversifying the number of committed sources of poultry litter across providers, providing an assurance of supply over time (based on chicken house cleanout schedules) and an assurance of suppliers should one or more suppliers be unable to continue supplying litter. The source percentages from the counties for this second set of credit scenarios are shown in Table 8.

Table 8. Information used to develop the second poultry litter source scenario. Source percentages were derived qualitatively from this information.[84]

County	Inter-County Manure Export / Import 1,000 dry tons net transfer	Number of Broilers	Distance from Duncannon (mi)	Source Percent
Lancaster	Export: 140 to 355	51,551,000	30	40%
Snyder	Export: 35 to 140	12,112,000	20	15%
Juniata	Export: 35 to 140	11,935,000	20	15%
Union	Export: 35 to 140	7,765,000	35	5%
Perry	Export: 35 to 140	3,981,000	5	10%
Schuylkill	Export: 35 to 140	3,306,000	35	5%
Lebanon	Export: 5 to 35	12,521,000	30	10%
Franklin	Export: 5 to 35	4,623,000	45	
Adams	Export: 5 to 35	659,000	25	
Dauphin	Neutral: -5 to 5	3,800,000	5	
Mifflin	Neutral: -5 to 5	1,167,000	30	
Berks	Neutral: -5 to 5	8,272,000	50	
Cumberland	Import: -5 to -20	3,228,000	10	
Northumberland	Import: -5 to -20	2,757,000	20	
York	Import: -5 to -20	2,111,000	20	
Montour	Import: -5 to -20	659,000	45	
Lycoming	Import: -5 to -20	503,000	50	

Assumptions for Poultry Litter Sources

For the nutrient credit calculations, the assumption was made that the poultry litter coming from the counties is currently being land applied in those counties to conventional tillage row crops. Since the identification of specific poultry operations as sources of litter in each county was not in the project scope, the delivery ratios were averaged across the watersheds in each county for credit calculation purposes. These assumptions have an influence on the number of nutrient credits that can be derived from the project.

[84] *Inter-county manure export/import data: Regional Manure Management Model for the Chesapeake Bay Watershed, 2005*

The PA DEP recommended factor of 85 percent was utilized when calculating the amount of the nitrogen in row crop applied poultry litter that is lost to the environment (i.e., potentially becoming nutrient loads). As part of the PA DEP recommended factor, it is assumed that 15 percent of the nitrogen in row crop applied poultry litter is taken up by the crops.

Replacement Nutrients for Current Uses

When the poultry litter under current conditions is no longer being applied to conventional tillage row crops, because it now will be exported to the combustion facility, those row crops will need replacement nutrients. For this manure to energy plant project, an assumption was made that those row crop fields will receive fertilizer applications in amounts that replace the nitrogen that was utilized by the row crops.

As part of this project, we are also assuming that a nutrient balance sheet is currently being utilized to apply the manure and fertilizer on the row crop fields currently receiving the poultry litter. Since those fields will now utilize fertilizer to replace the nutrients the crops used to receive from the poultry litter, it is assumed that those fields will now utilize a similar nitrogen management plan to precisely apply the necessary amount of startup fertilizer and subsequent fertilizer applications to provide the required nutrients to maintain crop yield. The PA DEP recommended factor of 50 percent was utilized for calculating the amount of the applied nitrogen fertilizer that is available for crop uptake. As part of this PA DEP recommended factor, it is assumed that 50 percent of the nitrogen in row crop applied fertilizer is lost to the environment (i.e., potentially becoming nutrient loads).

Phosphorus credits are being calculated for this project following the guidance of the PA DEP, which at this point is recommending that the net nitrogen credits be divided by 8 to derive the phosphorus credits.

As part of this project, it is encourage all farms that formerly received the poultry litter used for this project to convert from conventional tillage to conservation tillage or to no-till agriculture. We will additionally encourage all those farms to implement nitrogen and phosphorus management plans so that fertilizer nutrients are applied in the precise amounts needed to maintain crop yields. Nutrient credits could be derived for these best management practices that are implemented by those farming operations.

For nutrient credits to be derived from this combustion project, the farmers that had received the poultry litter and applied it to their row crops must replace that poultry litter with fertilizer. If they simply find another source of manure for application to their fields, then there may be no nutrient credits derived from this combustion project. If replacement manure is utilized on the fields, then the source of that replacement manure needs to be investigated to determine its source and replacement, and so forth, to determine if a nutrient load reduction has actually occurred. This required extensive tracking and may make credit trading extremely difficult.

Combustion Nutrient Products

It is recognized that the combustion facility will need to incorporate clean air technologies such as ammonia injection, which will convert NO_x into N_2 gas and water vapor. It is assumed for the purposes of this phase of the project that a coal fired power plant will, at some point, be taken off line to offset the addition of the power from this project to the electricity grid.

It is problematic to assume that nitrogen loads to the Bay from the air emissions of this project are exactly offset by the reduced emissions and consequent load reductions to the Bay from a coal fired power plant taken offline for grid balancing. The difficulty arises because we know that this project is located within the airshed of the Bay, while the coal fired plant taken offline at some point in time (coal fired power plants are much larger than 10 MW) may not be located in the airshed of the Bay. The PJM power grid, for instance, covers 13 states. Further, with the increasing power demands in the coming years, a power plant may not be taken offline at all.

A conservative approach was incorporated to account for the *potential* increase in NO_x emissions from this combustion facility. We have assumed that 2 percent of the nitrogen in the raw poultry litter entering the combustion facility will become nitrogen loads that reach the Chesapeake Bay. This percentage is conservative because the prevailing wind direction in the Chesapeake Bay watershed from the Duncannon location extends less than 80 miles to the east and southeast. We therefore assume that the majority of the NO_x emissions from the Duncannon facility will fall to the earth surface outside of the Chesapeake Bay watershed. Of that small portion that does fall to earth in the Bay watershed, some will be trapped on land features and some will enter water. The edge of segment and delivery ratios is then applied to that amount of NO_x that does fall to the earth in the Bay watershed.

Phosphorus is present in the ash that results from the combustion of poultry litter. At this point, it is projected that the ash will be land filled for this facility. The raw poultry litter is reduced in volume by about 90 percent after combustion, so that a 10 MW facility would produce about 6,400 tons of ash that would need to be land filled each year. With the land filling of the ash, there will be no phosphorus loads to the Bay from the solid byproducts of this combustion facility.

Nutrient Credit Scenarios
Eight nutrient credit scenarios were developed for this project, divided into to sets. These two sets reflect the two scenarios described above for the source of the poultry litter. Within each poultry litter source set, there are four scenarios for the four different sized combustion facilities.
The results for these eight nutrient credit scenarios are shown below.

Table 9. Annual nutrient credits for various output combustion facilities utilizing poultry litter from Lancaster County.

Combustion Plant Size (MW)	Annual N Load Reduction	Annual P Load Reduction
	(lbs/yr)	(lbs/yr)
2 MW	164,820	21,899
5 MW	412,056	54,748
7 MW	576,875	76,647
10 MW	824,098	109,494

Table 10. Annual nutrient credits for various output combustion facilities utilizing poultry litter from multiple counties (see Table 8).

Combustion Plant Size (MW)	Annual N Load Reduction (lbs/yr)	Annual P Load Reduction (lbs/yr)
2 MW	161,196	21,446
5 MW	402,997	53,616
7 MW	564,193	75,061
10 MW	805,981	107,229

As seen in these two tables, the nutrient credits are about 2 percent higher if only Lancaster County poultry litter is utilized. However, the multiple county source scenarios provide diversification in the sources of the litter. See Tables 9 and 10.

It is important to note that we are assuming the farmers currently utilizing the poultry litter will switch to fertilizer once that litter is utilized by the combustion facility. This is an important assumption because the farmers may be using the poultry litter at a cost that may be lower than the cost of replacement fertilizer. Other assumptions that affect the number of nutrient credits are the delivery ratios. In Lancaster County, for instance, if the poultry litter comes from farms that are all in the Conestoga River watershed, then the total nitrogen credits (see Table 9) are reduced from 824,098 lbs/yr for a 10 MW combustion facility to 779,012 lbs/yr. This is due to the different delivery ratios associated with proximity to the Bay. We have assumed that the poultry litter source farms are located throughout the counties, and we therefore averaged the delivery ratios for each county.

It was also assumed that there would be a 1:1 trading ratio for this project. This seems to be a reasonable assumption given that there is little uncertainty that this poultry litter will no longer contribute nutrient loads to the Bay. The calculation approaches used here are based on the guidance provided by the PA DEP. The calculation methodology may change in coming years, and this could affect positively or negatively the number of nutrient credits projected for this facility.

Of particular importance in the guidance provided by the PA DEP is the assumption that 85 percent of the nitrogen in poultry litter, when applied to row crops, is lost to the environment. Of this 85 percent of the nitrogen lost to the environment, half of it is assumed to reach streams (the edge of segment ratio). For Lancaster County, 96.5 percent of that nitrogen is assumed to reach the Bay (the delivery ratio). For poultry litter applied to row crops in Lancaster County, this guidance predicts that about 41 percent of the nitrogen in that poultry litter reaches the Bay. These edge of segment and delivery ratios are critical elements in the calculation of nutrient credits.

Given these project and credit assumptions, the nutrient load reduction benefits to the Bay from this project are significant. For a 10 MW poultry litter to energy facility, load reductions of over 800,000 lbs of nitrogen and 100,000 lbs of phosphorus will occur annually.

Chesapeake Bay Tributary Strategies

The Lower Susquehanna River East watershed, encompassing the Bay portions of Lancaster, Dauphin, Chester, Berks, Schuylkill, and Lebanon counties, and part of Perry, Snyder, and Juniata counties, has a year 2010 targeted nitrogen load reduction of 7.8 million lbs of nitrogen annually from nonpoint sources. Assuming that the poultry litter for this project comes entirely from the Lower Susquehanna River East watershed, the proposed combustion facility at 10 MW could provide about 10 percent of the annual nonpoint source nitrogen load reduction needed for the Lower Susquehanna River East watershed. In a similar comparison, the proposed combustion facility at 10 MW could provide nearly half of the year 2010 targeted 224,000 lbs per year nonpoint phosphorus load reduction for this watershed.

LIFE CYCLE ASSESSMENT – EXECUTIVE SUMMARY

Introduction

Balancing environmental, social, and economic costs and benefits enables society to make decisions and behave in ways that ensure the on-going availability of resources. This approach is what we refer to as "sustainable" and can refer to agriculture, development, industry, and many other enterprises and activities. A powerful tool that can be used to help quantify costs and benefits and guide decision-making is the Life Cycle Assessment (LCA).

An LCA objectively reveals the consequences of our actions in all parts of a complex, ecologically based system and helps us avoid unintended or unforeseen consequences. Using inputs and outputs, the assessment compares current practices to the proposed future scenario to determine the net environmental impact, positive or negative.

LCA is based on methodology outlined in the International Standards Organization documents (ISO 14040), which, according to its web site (http://www.iso.org/iso/about.htm), is a world-wide organization that "enables consensus to be reached on solutions that meet both the requirements of business and the broader needs of society," and "forms a bridge between the public and private sectors." An LCA makes certain assumptions and uses standard published data for some inputs. LCAs also assume worst-case scenarios so that benefits are not overstated.

The LCA undertaken on behalf of the Borough of Duncannon considers the use of chicken litter as a biofuel to generate electricity. The current scenario includes 1) applying chicken litter to land in the Chesapeake Bay watershed as fertilizer to grow corn, and 2) using coal to generate electricity. The future scenario includes 1) using precision applications of commercial fertilizer to land in the Chesapeake Bay watershed to grow corn, which will require additional production of commercial fertilizer, and 2) using chicken litter to generate electricity, which allows a coal-fired power generation plant to be taken off line. The assessment assumes no changes in practices associated with the chicken house. The following table summarizes the comparison between the current approach and the future state:

Table 11. Comparison of Current and Future Scenarios.

Inputs & Outputs	Current	Future
Corn field input	Chicken litter & commercial fertilizer	Commercial fertilizer
Corn field output	Corn	Corn
Power plant input	Coal	Chicken litter
Power plant output	Electricity and/or Steam	Electricity and/or Steam

Life Cycle Impact categories in this assessment include:

- Primary Energy Demand of nonrenewable resources
- Global Warming Potential (GWP)
- Ozone Depletion Potential (ODP)

- Acidification (acid rain) Potential (AP)
- Eutrophication Potential (EP) (nutrient contribution to the Chesapeake Bay)
- Photochemical Ozone Creation (smog generation) Potential (POCP)

Discussion

Environmental benefits of using biomass versus fossil fuel are quantifiable. Environmental benefits of reducing the amount of chicken litter applied to land that drains into the Chesapeake Bay, and therefore reducing nutrient runoff into the Bay, also are quantifiable. (Benefits of reducing nutrient runoff are discussed in the report.) However, the LCA takes into account that reducing the amount of chicken litter applied to the land increases the amount of precision-applied commercial fertilizer needed to maintain agricultural productivity. It evaluates the production of the fertilizer as well as its impact in the watershed. Likewise, the environmental and economic costs of transporting chicken litter from the farm to the power plant are included in the assessment.

The LCA includes all processes within the entire system associated with the scope of the study. All inputs of mass and energy (resources) are accounted for, as are outputs of "product" and associated wastes generated to land, water, and air. Of particular interest is the impact of transporting chicken litter from outlying farms to the central power plant. The assessment assumes full truckloads of chicken litter and an average hauling distance of 25 miles. The model shows that fuel use and truck emissions are negligible when compared with the fuel value of the 25 tons of chicken litter hauled in each truckload.

When considering the discharge of ash from the power plant, the assessment assumes proper disposal of the ash in an approved landfill. The project's future intent would be to find beneficial use for the nutrients contained in the ash; an updated LCA would reflect that total environmental impacts are reduced for the system.

The assessment assumes a power plant design that employs combustion of the biofuel chicken litter. The assessment further assumes that the air discharge from the power plant is not scrubbed. The output of this assessment shows that scrubbing equipment will be required for a properly designed power plant. Appropriate air-pollution abatement equipment will hold emissions below State (PA DEP) regulatory limits.

The assessment compares the power plant with and without heat recovery equipment. A Combined Heat and Power (CHP) facility in which the energy embodied in the spent steam is recovered provides a clear benefit in all categories, including economic.

Results and Conclusions

- The use of chicken litter as a biomass fuel improves the overall environmental impact of the system.
- Proper air emission controls for the power plant are mandated to reduce waste to below allowable limits.
- Including a CHP system in the future scenario more than doubles the total energy recovery from the current "power only" level of approximately 32% to a "power and heat" level of approximately 67%.

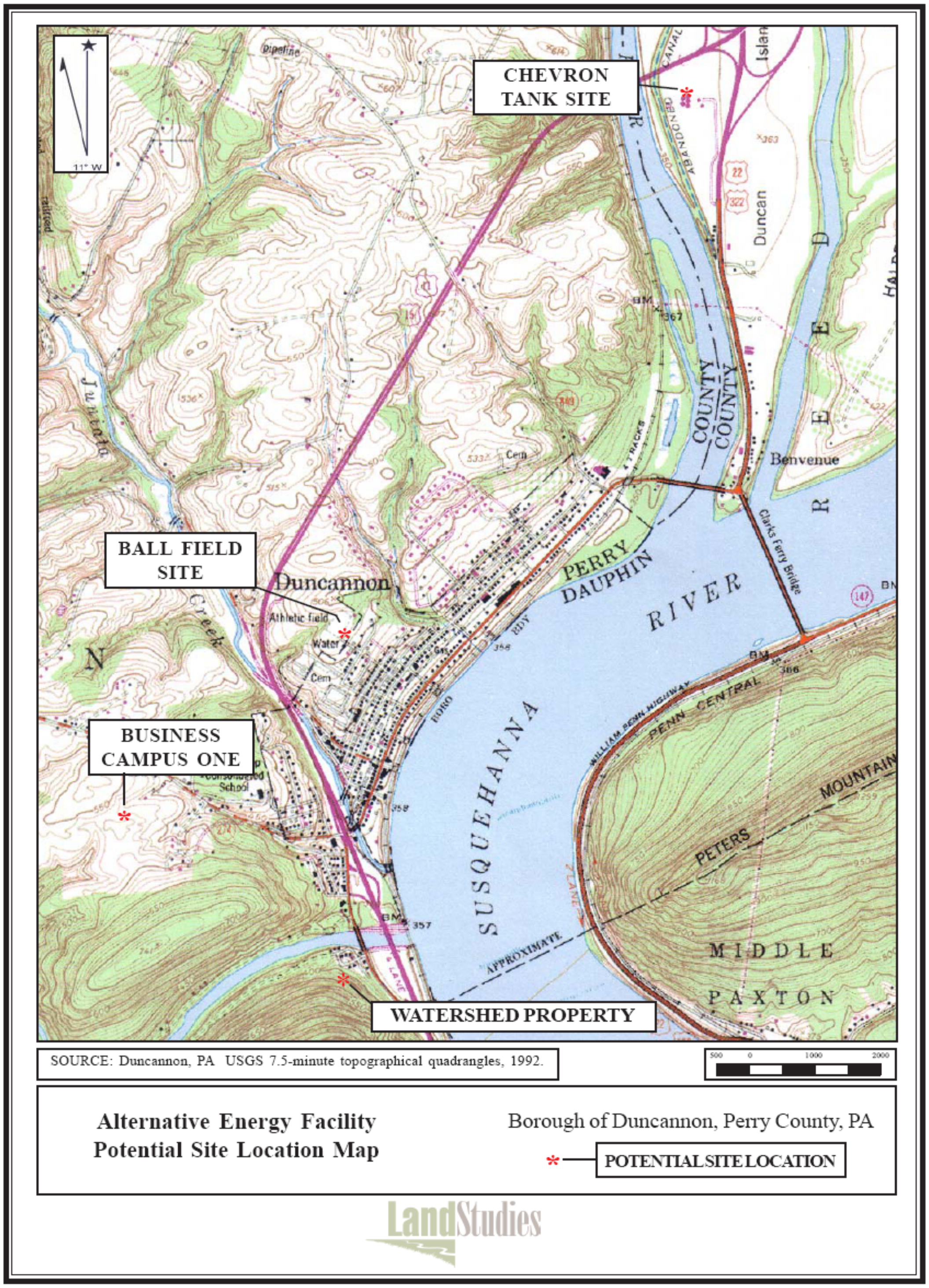
    - A steam host would be required for a CHP power station, which means that the chicken litter combustion plant should be located next to a user of thermal energy.
- Substantial nutrient reductions to the Chesapeake Bay watershed are realized.
- The use of chicken litter to generate electricity reduces dependence on fossil fuel.

See full Life Cycle Assessment report in Appendix 2.

POTENTIAL SITES FOR ENERGY PLANT

Though the project is only in the feasibility stages, the Borough of Duncannon had suggested several potential site locations which could accommodate the manure to energy plant. Four of these locations are summarized below. See Figure 11.

Figure 11. Duncannon Manure to Energy Site Location Map.



Watershed Property

Description

The Watershed Property is a 2,500 acre parcel owned by the Borough of Duncannon, but located in the adjacent municipality, Penn Township. It is located on the south side of Sherman Creek, with the Susquehanna River and Route 11/15 directly to the east. The land use and cover is primarily forested. The topography is steep, with significant drainage to Sherman Creek. The easiest access to the site is at the northwest corner of the property through a small residential area with approximately 10-15 dwellings.

History

Traditionally, the property has been used by the community for hiking, walking, swimming, wildlife viewing, and other outdoor recreational activities. It has also been a place of research on flora, fauna, and habitat conducted by the Sherman Creek Conservation Association, local Scouts, other organizations, and individuals. Some of this research included water quality studies conducted on the property. The property is also rich in natural resources. There are 9-10 forestry tracts divided throughout the property that are timbered on a 20-year rotation cycle and managed by a local forester. The Borough of Duncannon uses several wells located on the property as a source for its water supply. A Wellhead Protection Plan protects these wells from contamination.

Pros: Property owned by the Borough of Duncannon;
No land acquisition or lease costs.

Cons: Property lies within Penn Township;
Subject to Penn Township regulations and ordinances;
Limited potential for steam host;
Potential for "NIMBY" public response;
Limited accessibility.

Environmental Constraints

The presence of several species on the State's Special Concern, Threatened, or Endangered Species list has been confirmed by a local biologist. These species include the four-toed salamander, northern leopard frog, bald eagle, osprey, great egret, and white milkweed. The property contains a diversity of habitat for reptiles, amphibians and other critical species. The presence of these unique species and habitats could make locating a manure to energy plant very difficult due to permitting requirements and restrictions.

The Pennsylvania Department of Environmental Protection (PA DEP) is currently undergoing the process of evaluating Sherman Creek for the re-designation of its protected water use from *Warm Water Fishes* (WWF) to *Exceptional Value Waters* (EV) between Cisna Run and the confluence with the Susquehanna River. If the Environmental Quality Board rules to re-designate Sherman Creek as EV, development within the Sherman Creek Watershed will be faced with additional regulations as EV is the highest level of protection in the State.

Archeological Constraints
Due to its proximity to the Susquehanna River and Sherman Creek, there is a high likelihood for Native American artifacts to be present in the area. Artifacts are typically located in close proximity to streams and rivers because local communities of Native Americans used these places to camp. Based on current information, there is an unverified account of an area that resembles a Native American encampment and some rock outcroppings that may contain Native American paintings.

General Site Constraints
Even though the property encompasses approximately 2,500 acres, there is a lack of suitable topography necessary to support the layout of an alternative energy plant. In addition, access to one of the more suitable areas for a facility is limited by a residential area consisting of approximately 10-15 dwellings. Gaining daily access through this area for trucks could be problematic. Source Water Protection limitations based on 100-150 foot development offsets could also be a constraint on site selection depending on the specific location of the plant.

Conclusion
It is the professional opinion of LandStudies that this site is not an ideal location for the development of an alternative energy plant. Based on our experience and expertise, the constraints listed above are likely to significantly increase the complexity, expense, and timeframe of the permitting process. Due to the natural wildlife diversity, potential for historical artifacts, and potential for the re-designation of Sherman Creek to exceptional value, compliance with the Pennsylvania Natural Heritage Program (PNHP), Pennsylvania Historical and Museum Commission (PHMC), Pennsylvania Fish and Boat Commission and United States Fish and Wildlife Service could be extremely expensive and timely. In addition, disturbance and development of the property may cause overwhelming public concern and disapproval. For these reasons, it is difficult to reconcile the negative impacts of an alternative energy facility on an ecologically and historically sensitive site. The Borough of Duncannon has a large parcel of continuously forested land which is an asset to the community, the watershed, and the environment. We recommend preserving this property and looking for more suitable tracts of land which better lend themselves to this type of project.

Business Campus One

Description
Business Campus One is a business park located in Penn Township approximately one mile to the west of Duncannon Borough. Currently, there are available parcels of land zoned for commercial use within the campus. Perry County Economic Development Corporation is the entity that manages Business Campus One with the Department of Community and Economic Development and the Federal government. Due to federal grants related to this economic business park, no public entity can be an owner. There are possible ordinances for odor, noise, profile, and traffic.

History
LandStudies contacted High Associates, Ltd., who is responsible for the marketing of the lots to discuss the potential for an alternative energy facility at the campus. High Associates revealed that there was interest in trying to market green attributes from an alternative energy project. However, allowable uses might exclude this type of tenant. When speaking with the Executive Director of the Capital Region Economic Development Corporation, LandStudies was asked to send an information packet to the corporation so they could discuss this type of use at the campus during their next board

meeting. PPL Corporation is the electricity provider for the campus and United Water is the water utility provider. LandStudies sent a packet of information and is still awaiting feedback. Many of the parcels at the campus still remain empty after several years, so there may be some difficulty in filling the lots.

Pros: Sufficient accessibility and infrastructure for plant;
Limited environmental constraints;
Potential for steam host.

Cons: Lots currently zoned commercial (Industrial rezoning required);
Property located in Penn Township;
Potential for "NIMBY" public response;
Potential limited use due to odor, noise, and traffic ordinances.

Conclusion
Locating an alternative energy facility on a developed lot may significantly reduce costs, but can add unwanted constraints as well. Because the campus is zoned commercial and already has ordinances in place, it may be very difficult or even impossible to gain approval for an industrial, energy producing facility. If the Borough chooses to consider Business Campus One as a place to build an alternative energy plant, it will be essential to contact the Capital Region Economic Development Corporation and High Associates, Ltd. to set up a meeting to discuss the feasibility of this option.

Ball Field Site

Description
The Ball Field Site is an athletic field complex located in Penn Township, adjacent to Duncannon Borough.

History
According to the limited amount of information gathered pertaining to this site, the property is maintained by Duncannon Borough and is used infrequently.

Pros: Contiguous to Duncannon Borough property;
Potential for annexation which would enable full control of property;
Adequate accessibility;
Potential for steam host;
Close proximity to undeveloped tracts of land.

Cons: Potential for "NIMBY" public response;
Potential issues associated with annexation and re-zoning.

Conclusion
Despite the need for re-zoning, the Ball Field Site is likely the most practical option for the location of manure to energy plant. There are less site constraints at this location and it is best suited geographically. Because it is adjacent to Penn Township, this is the only site discussed that could be annexed to the Borough. If annexed, the Borough will gain full control of this site. Adequate site access, close proximity to Route 11 and the Borough, potential for steam hosts, and the lack of

significant site constraints known at this time make the Ballpark Field Site the most desirable option for a manure to energy plant.

Chevron Tank Site

Description
Very little information is known about this site. The site is located on Rt. 322 between the Susquehanna River and Juniata River.

History
This site was used for petroleum storage tanks during the 1970's and 1980's. There have been large quantities of fill imported to the site to protect against flooding. The current use and owner of the land is unknown at this time.

Pros: Redevelopment of industrial site;
Land acquisition costs may be reduced due to previous use;
May already be zoned industrial;
Sufficient access to major highway.

Cons: Long distance from the Borough of Duncannon (transmission difficulty);
On the banks of the Juniata River;
Potential floodplain encroachment;
Possible environmental constraints due to previous use;
Limited steam host potential.

Compared to the other sites, the Chevron Tank Site is the furthest from the Borough. The Juniata River flows between the site and Duncannon. This acts as a significant barrier for the transmission of electric and steam back to Duncannon. There may be significant environmental constraints on this property as well because of its previous use storing petroleum products. Close proximity to the Susquehanna and Juniata Rivers may cause issues with flooding and floodplain ordinances. There is also no known demand for steam nearby.

Conclusion
Based on the current information, the Chevron Tank Site would be an undesirable location for a manure to energy plant because of its distance from Duncannon, close proximity to the Susquehanna River which floods frequently, and potential environmental hazards resulting from prior petroleum usage on the site. On the other hand, there may be special programs and funding from the state and federal government available to municipalities interested in cleaning up this site and utilizing it. All things taken into account, the Ballfield Park Site and Business Campus One should be considered before exploring the options at the Chevron Tank Site.

BENEFITS OF MANURE TO ENERGY PROJECT

Borough of Duncannon

The Borough of Duncannon could benefit in several ways from a poultry manure power plant. The most important benefit to Duncannon is that the power plant could provide a more stable source of electricity at a steady price as compared to fossil fuel powered energy. The development of a manure to energy plant could help to reduce the electricity costs which will increase after deregulation in 2010 (Refer to *Electric Generation* section). Potential ownership by the Borough could further help to alleviate these increasing costs.

The price of generating power is ever increasing due to the lack of reliable, cheap, renewable fuels. Poultry manure is a fuel that has all three of these characteristics. Because south central Pennsylvania is one of the largest producers of poultry manure in the Chesapeake Bay Watershed, there is a steady source of fuel for a poultry manure power plant. The proposed manure to energy plant would effectively utilize excess manure as a fuel to generate power. There are minimal costs associated with obtaining the manure. The Borough would also be credited with removing thousands of pounds of nitrogen and phosphorous from the Chesapeake Bay Watershed.

Additional revenue is another benefit that could be gained from the development of a manure to energy plant. First, the Borough was to build a plant that would generate more than 2 megawatts of power, excess electricity could potentially be sold back to the grid at market price. Secondly, Renewable Energy Credits and Carbon Credits could be obtained by burning a renewable fuel such as poultry manure. The credits can be sold separately from the generated electricity and, in turn, provide additional revenue to the Borough. Electric companies, who do not produce renewable energy, are able to buy the RECs to offset their traditional power generation. The price of a REC has not been solidified because it is market driven and the market is still being developed (Refer to *REC and Carbon Credit* section). Last, the removal of manure from farm fields could potentially generate nutrient credits which could in turn be sold and traded similarly to RECs and Carbon Credits.

Currently, the Fibrominn project in Minnesota is the only other poultry manure fueled power plant in the United States. A manure to energy power plant, if constructed for the Borough of Duncannon, may be the first of its kind on the East Coast. The project stands to be a model for other proposed energy plants and generate various forms of positive publicity for the Borough and the state of Pennsylvania.

Agriculture

In order to assist in compliance with Act 38 and Act 49, a manure to energy plant would provide poultry producers with a constant outlet for excess manure. The plant would help reduce farm costs by providing trucking to pick up the manure from the farm during the poultry house “clean-outs”. Producers that provide manure to the power plant may also be eligible to receive nutrient credits. These credits could be sold at the market price to nutrient generating operations such as wastewater treatment facilities. This could prove to be an additional source of income for the poultry farmers.

Environment
Excess nutrients contained in manure, which are a non-point pollutant, represent half of the nutrient load to the Chesapeake Bay.[85] However, non-point source pollutants are extremely hard to monitor. By acquiring excess manure from farming operations, the potential pollutant is converted from a non-point source to a point source pollutant which is much easier to manage and quantify. Essentially, utilizing manure as a fuel source instead of fertilizer helps to reduce nutrient loading in the Chesapeake Bay.

A manure to energy power plant also stands to emit less pollution than a coal-fired plant. As with any combustion process, the plant will generate air pollutant emissions. However, the emissions that are generated from a manure to energy plant have a different composition than those generated by coal fired plants. The burning of poultry litter will not introduce new carbon dioxide into the atmosphere because the process recycles carbon that already exists in the environment. Regardless of the type of emissions released from the manure to energy plant, all emission sources are required by the CAA to install appropriate abatement technology to manage regulated pollutants. Refer to *Emissions and Waste Residuals* section.

State Agencies
In 2004, the Alternative Energy Portfolio Standards Act of 2004 (ACT 213) was enacted to require 18% of electricity generated by electric utilities companies to be from renewable resources. Of the 18%, 10% is required to be from Tier 1 and 8% from Tier 2. If approved by PA DEP as a form of biomass, the Duncannon project could provide a source of Tier 1 renewable energy for other electric utilities to purchase. Table 12 summarizes the percentage of renewable energy generated by four potential manure to energy plant capacity. If successfully implemented, the plant could serve as a model for future renewable energy projects. This type of energy production would also help to meet the stipulations of the AEPS.

Table 12. Percentage of Pennsylvania's renewable energy generated by a manure to energy plant.

Power Plant Capacity	% of PA's Renewable Energy
2 MW	0.04
5 MW	0.10
7 MW	0.15
10 MW	0.20

85 Baranyai, V. and Bradley, S. "Turning Chesapeake Bay Watershed Poultry Manure and Litter into Energy: An Analysis of the Impediments and the Feasibility of Implementing Energy Technologies in the Chesapeake Bay Watershed in Order to Improve Water Quality." Chesapeake Bay Program Office. July 2007.

SOURCES OF PUBLIC FUNDING

State Programs

1. Pennsylvania Energy Harvest Grant Program
Annual $5 million in PA DEP grants for the support of clean advanced energy projects, including renewables, coal mine methane, waste-coal reclamation for energy, innovative energy efficiency projects and clean distributed generation infrastructure improvements.

$5.1 million in grant funding was invested in 27 projects throughout Pennsylvania in 2006.

- $346,884 was granted to Applied Reclamation Techniques, Inc. for a biomass heat system that will supply building and process heat for the new Schuylkill County Agricultural Facility in Quakertown, Schuylkill County, PA. The system is proposed to use 1,300-1,800 tons of poultry litter per year. The project is estimated to remove 39 tons of nitrogen, 26 tons of phosphorus and 26 tons of potassium every year.

- $285,038 was granted to Southern Alleghenies Conservancy, Inc. to build a complete-mix anaerobic digester system in Juniata County. Using dairy manure as fuel, it will produce 69,281 kilowatt hours of electricity per month to sell to electric distribution companies.

- $375,134 was granted to John Koller & Son, Inc. to build an anaerobic digester in Mercer County that will produce biogas to power a 120 kilowatt electrical energy generator.

2. Pennsylvania Venture Guarantee Program
The program provides $250 million over a 4-year period to provide guarantees to venture capital partnerships for investments in Pennsylvania-related companies that are in early or mid-stage development. For more details visit: www.newpa.com

3. Pennsylvania Energy Development Authority
This annual $10 million in funding for grants, loans and loan guarantees is for clean, advanced energy projects. Additionally, the Pennsylvania Economic Development Financing Authority (PEDA) can help support issuance of hundreds of millions of tax exempt or taxable bonds to fund energy projects.

4. Pennsylvania Economic Development Financing Authority
PEDFA can issue tax-exempt and taxable bonds to finance energy projects. The bonds may be used to finance land, building, equipment, working capital or re-financings. PEDFA may be used to finance up to 100 percent of project costs and, for energy projects, no maximum limit has been set. Contact Craig Petrasic, 717-783-1109 or crpetrasic@state.ps.us

5. Sustainable Energy Funds
Primarily financing and equity investments (some small grants) for renewable energy project, renewable fuels and energy efficiency. The funds are divided into geographic regions. Contact Rex D’Agostino, The Sustainable Energy Fund of Central Eastern Pennsylvania, 610-264-4440 or RADAgostino@theSEF.org (Service Territory: PPL)

6. First Industries
The program provides $150 million over four years in financial assistance in the form of loans, grants, and loan guarantees for projects related to the development of tourism and agriculture. Two-thirds of the program's funding is devoted to agriculture. Qualifying projects include those that will result in energy efficient agricultural operations. For more details please visit: www.newpa.com

7. Machinery and Equipment Loan Fund
Low interest loans up to the lesser of $5 million or 50 percent of project costs to those involved in industrial processing, manufacturing, mining, production agriculture, information technology, or biotechnology. Funding must be directly related to the industrial, manufacturing, agricultural, or mining operations of the applicant and must create at least one job for every $25,000 in financing. Contact: Steven Clarke 717-720-1410 or stclark@state.pa.us

Federal Programs

1. Alternative Fuel and Vehicle Incentives
This website offers links to several state and federal incentive programs for things such as hybrid vehicles, alternative fuel usage, biodiesel, and many others. For more information please visit: U.S. Department of Energy's Alternative Fuels Data Center
http://www.eere.energy.gov/afdc/incentives_laws.html

2. U.S. Department of Agriculture (USDA) and U.S. Department of Energy
The U.S. Department of Agriculture (USDA) and the U.S. Department of Energy (DOE) offered a combined total of up to $18 million for research and development of biomass-based products, biofuels, bioenergy and related processes. USDA and DOE are issuing these grant solicitations for several types of projects aimed at increasing the availability of alternative and renewable fuels.

The USDA and U.S. Department of Energy invested $23 million for 19 projects involved in biomass research and development.

- $1.1 million was granted to Earth Resources, Inc. to construct a 20-MW power generating station utilizing chicken poultry mixed with woody biomass as fuel by gasification in Franklin County, Georgia.[86] Earth Resources, Inc. is also working on a grant from the National Renewable Energy Lab in Golden, Colorado.[87]

3. National Renewable Energy Lab – Golden, Colorado
The National Renewable Energy Laboratory (NREL) is the nation's primary laboratory for renewable energy and energy efficiency research and development, which focuses on advancing the energy goals of the U.S. Department of Energy and the nation. This organization assists governments,

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[86] Hatcher, Beth. "Plant Receives $1.1 Million Grant." Athens Banner-Herald. September 2003. www.onlineathens.com/stories/091003/new_20030910046.shtml

[87] Crotty, Patrick. "Plan Hatched to Harness Power of Chicken Manure." Athens Banner-Herald. August 2003. www.onlineathens.com/stories/082503/new_20030825022.shtml

organizations, universities, and industry worldwide with the selection, design, and management of renewable energy, energy-saving, and distributed energy technology solutions. The NREL's Federal Energy Management Program (FEMP) provides guidance to government agencies on innovative project financing methods including Energy Savings Performance Contracts (ESPCs) and Utility Energy Services Contracts (UESCs).[88] For more information please visit www.nrel.gov or contact Karen Thomas (UESCs) or Douglas Dahle (ESPCs).

4. National Fish and Wildlife Foundation's Chesapeake Bay Target Watershed Program

This program provided $1 million in funding to Virginia Tech in Blacksburg, Virginia for research and development of a mobile pyrolysis unit that uses poultry litter as fuel. The self-contained, transportable pyrolysis unit will allow poultry producers to process litter on-site. The biogas generated will be used to power the system, the bio-oil will be used to heat poultry houses, and the char will be used as a low-release fertilizer.[89] This was part of a larger effort to support the agricultural community while managing excess nutrients in the Shenandoah Valley. For more information please visit:
http://www.nfwf.org/AM/Template.cfm?Section=Browse_All_Programs&CONTENTID=8011&TEMPLATE=/CM/ContentDisplay.cfm

5. Natural Resources Conservation Services (NRCS)

Conservation Innovation Grants (CIG) is a voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging Federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, Environmental Quality Incentives Program funds are used to award competitive grants to non-Federal governmental or non-governmental organizations, Tribes, or individuals.

- Natural Resource Concerns category—Up to $10 million available for proposals addressing one or more of the CIG natural resource concerns. This component was also offered in 2004, 2005, 2006 and 2007.
- Technology category—Up to $5 million available for proposals addressing one or more of the CIG technology categories. This component was offered in 2006.
- Chesapeake Bay Watershed category—Up to $5 million available for proposals addressing one or more of the CIG natural resource concerns in the Chesapeake Bay watershed. This component was also offered in 2005, 2006 and 2007. For FY2008 the National Fish and Wildlife Foundation (NFWF) will be accepting and reviewing applications for this category. For information on submitting an application for this category please visit www.nfwf.org/chesapeake.

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88 National Renewable Energy Laboratory Website. www.nrel.gov. January 22, 2008.

89 Schill, Susanne R. "Mobile Pyrolysis Plant Converts Poultry Litter to Energy." Biomass Magazine. November 2007.

For more information please visit:
http://www.nrcs.usda.gov/programs/cig/pdf_files/CIG08_APF_Final1_Web_and_e-grants.pdf

- Partial funding for a $600,000 small-scale gasification unit manufactured by Westwood Energy on a poultry farm owned by Josh Frye in Wardensville, West Virginia.

CONCLUSION

The planning and development of the proposed manure to energy power plant will require the consideration of many factors. Although the concept has only recently begun to be considered in the United States, a manure to energy plant serves as a practical and reasonable way to provide energy to a region while removing excessive nutrients from the environment. As with any newly presented concept, it must be understood that for as many people that support the idea, there will be a number of those who are opposed. It is important that the research and development of poultry derived fuels to energy technology continues to properly educate the public of the benefits of such technology. In the case of the Duncannon plant, several questions must be answered to begin the planning and development process including:

1) What is the output of the plant going to be?
2) If the plant generates more electricity than needed, who will buy the excess?
3) How much manure will be needed and where will it come from?
4) What fuel mixture will be used?
5) What technology will be used to generate electricity?
6) Will there be steam revenue generated from the distribution of excess steam for CHP?
7) Who will provide funding to build the plant?

To help answer these questions, this feasibility study developed a hypothetical scenario in which a manure to energy power plant would be constructed within or near Duncannon, Pennsylvania. The plant would provide at least 2 megawatts (MW) of electricity for the Duncannon residents using poultry litter as a fuel source with any excess being sold to the grid to create additional revenue. Poultry litter would be trucked from manure exporting poultry farms within a 50-mile radius of Duncannon. However, it may be economically feasible to obtain fuel from as large as a 100-mile radius depending upon transportation costs. The Life Cycle Assessment (LCA) summarizes the amount of fuel that would be necessary for a 2, 5, 7, and 10 MW plant based on using traditional direct combustion. Wood waste would be added to the poultry litter to create a uniform fuel (70% poultry manure and 30% wood waste) which combusts more efficiently.

If it is possible to burn a consistent supply of broiler litter with uniform composition, direct thermal combustion systems may be the most appropriate technology for the Duncannon power plant. This will require communication with poultry integrators and poultry farmers to establish standardized operations and maintenance procedures including handling methods, temporary storage methods, efficient clean-out schedules, etc. Clean-out schedules among individual farms should be coordinated to maintain a steady inflow of fuel without having more than what the power plant facility is able to store. If other types of biomass fuels will be incorporated or inconsistent litter composition is foreseen, a circulating fluidized bed boiler system may be more appropriate. Each type of system has demonstrated overall efficiency and flexibility with burning a variety of fuel types.

Perhaps the most significant factor involved with making a manure to energy plant more economical is the use of excess steam to generate combined heat and power (CHP). If the plant will provide CHP, the plant should be located near a suitable steam host. Suitable steam hosts are typically large facilities, such as hospitals, manufacturing operations, prisons, universities, etc. that need to maintain uniform heating and cooling throughout the year. The steam, which would normally be wasted, could be sold to a potential steam host at better prices than fossil fuels which are typically used to generate CHP.

The major conclusions of this report show that a manure to energy plant could be placed in the Duncannon area based upon available fuel supply and the fact that it will improve regional air and water resources when compared to traditional electric generating facilities. This feasibility study offers general guidance for implementing a manure to energy plant. However, no definitive decisions can be made regarding the details of a plant until a site is selected. Final site selection will begin to answer the questions above in more detail. The vision for Phase III of this project would include more detailed analysis of site conditions and restraints.

Recommendations

Economic Funding

- Due to revenue potential, the market for ash use should be further pursued and developed. Ash (power plant by-product) can be utilized in fertilizer as well as other materials but the market has not fully developed. Using the ash in this way could significantly reduce the cost of disposal for the power plant.
- Nutrient trading offers another potential revenue source that is still in need of market development. Currently, credits are being traded, but the value of a credit is still variable.
- The market for REC's (renewable energy credits) is more developed than the market for carbon offsets. It needs to be determined which incentive can provide more substantial revenue in the long term.
- For the best economic feasibility, the power plant should be located near a steam host that will utilize the excess medium-pressure steam that is generated from the power plant. The power plant could be much more financially successful if a steam host were available.

Fuel

- In order to solidify a reliable source of poultry manure to fuel the power plant, it will be necessary to get a commitment from enough farms to supply the required fuel allocation. A long term contract with the poultry farms would also be important to reassure the availability of the manure.
- A detailed trucking logistics plan will be required to ensure that the manure will be transported to the power plant as efficiently as possible.
- Alternative fuel sources will also need to be coordinated if for any reason chicken manure is not readily available.

Site Location

Any site considered should:

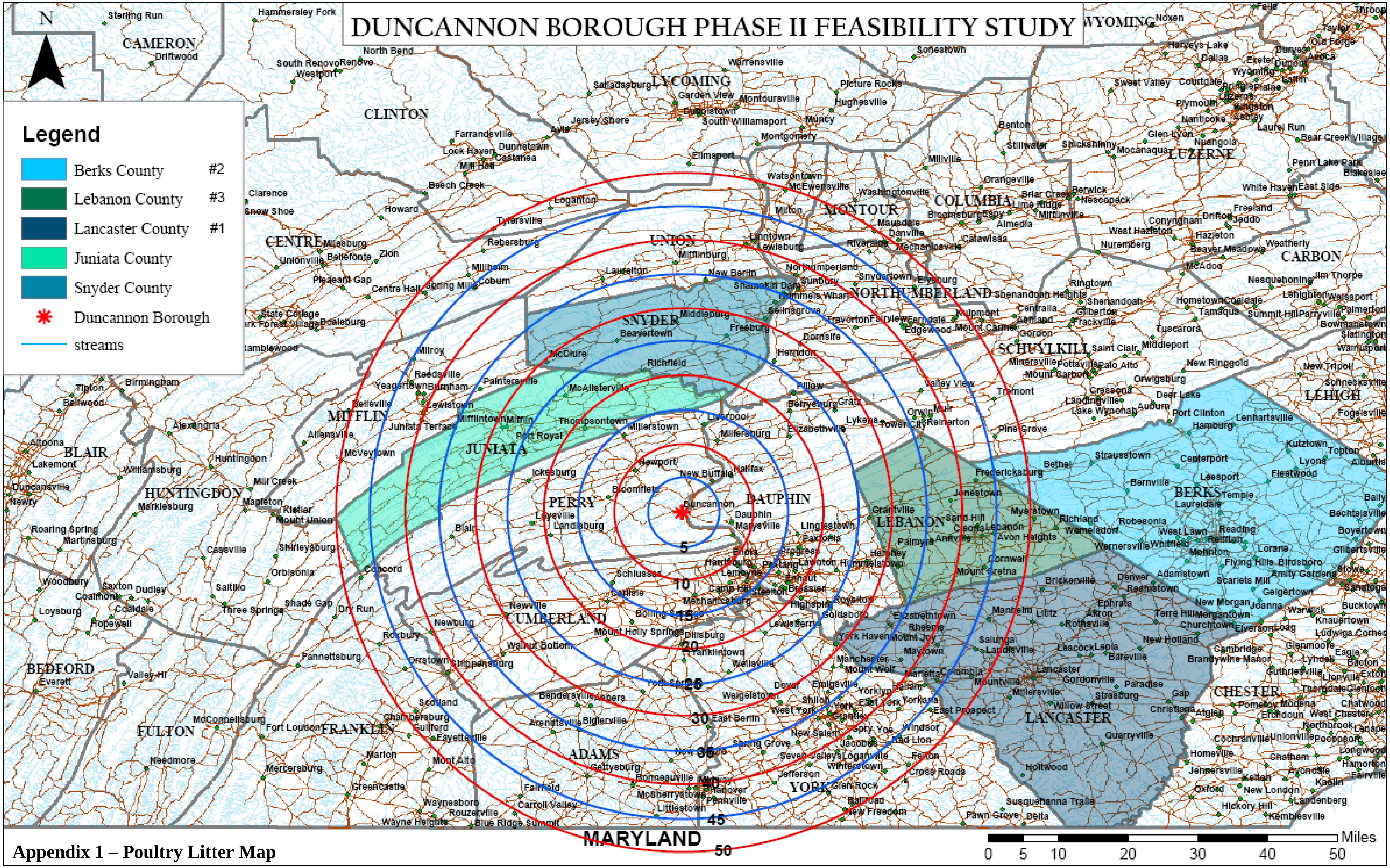
- Be easily accessible to a major roadway.
- Try to minimize negative perception from the public.
- Be located within reasonable proximity (50 miles or less) of potential fuel sources.
- Have a readily available and clean source of water.
- Be located adjacent to or in close proximity to a facility that can utilize the excess steam from the plant (steam host).

Technology

The technology considered for a plant of this type should:

- Use technology that is adaptable to a variety of fuel types.
- Consider utilization of combustion, gasification, or a combination of combustion and gasification technologies depending on fuel combination.
- Be capable of dealing with a fuel source with varying moisture content.
- Consider co-firing with another fuel source such as wood waste.

APPENDICIES



Appendix 1 – Poultry Litter Map

Appendix 2—Life Cycle Assessment

Sustainable development is a fundamental requirement for future living conditions. Hence the question arises how to analyze ecological aspects of industrial operations in a comprehensive and objective manner. Life Cycle Assessment (LCA) is an appropriate tool for supporting environment-orientated studies. With this method a variety of environmental effects can be covered taking into consideration the entire life cycle of a product or process. A correct application of the method provides quality results which are highly accepted following standardized and coordinated procedures. The concept of an LCA is mainly concerned with the following basic aspects:

- the observation of the whole life cycle of a product - from raw material acquisition, processing and production to its use, recycling and disposal.
- the coverage of all those impacts associated with the life cycle on the environment, such as raw material and energy consumption, use of land (input flows), emissions to air, water and land, as well as waste (output flows).
- the aggregation and assessment of these impacts in view of the possible effects on the environment with the aim of assisting environment-oriented decisions.

An impact assessment is carried out on the basis of an inventory analysis data. These data are categorized according to their potential impact on the environment in so-called impact categories. These categories describe the potential environmental impacts and not the actual effects, since the real effects depend on broader parameters which are not registered by an LCA. This includes, for example, spatial and temporal parameters since an assertion over actual environmental impacts is connected with the where and when the emissions, which have been added up, have actually been released.

Such an impact category is, for instance, the global warming potential. All emissions which produce a potential contribution to the greenhouse effect are assigned to this category. The most well-known emission in this category, due to the current discussion, is carbon dioxide. In classifying the inventory data according to their potential environmental impacts, an aggregation of the number of impact categories takes place. The number of the data is therefore considerably reduced and the results can be better interpreted by referring directly to the environmental impacts. Since the inventory data are related to the functional unit, this relation also exists in the life cycle impact assessment. These results and data obtained from the inventory analysis can be used for the interpretation phase of an LCA.

Life Cycle Analysis on the current and proposed practice

A Life Cycle Assessment was performed to allow an environmental comparison between the current practice of spreading chicken litter on the local fields and the proposed practice of utilizing the chicken litter as a biomass fuel source to generate" electricity. Environmental impacts have been calculated for different scenarios to get information on how the environmental impacts will change when the chicken litter is burned to produce energy (future scenario) instead of used as fertilizer in corn production (current scenario). A complete system with defined system boundaries and functional units was set up to be able to compare the scenarios. In the current practice all chicken litter is assumed to be distributed onto local fields in the Chesapeake Watershed and all electricity is assumed to be produced with fossil fuel. In the future practice, the fields will be fertilized with commercial fertilizer and the electricity produced with the biomass will replace a coal burning power plant. It is further assumed that the practice at the chicken house will not be substantially altered in the future state.

In the current scenario corn is produced using 20 % chicken litter and 80 % commercial mineral fertilizer. The amount of nitrogen, P2O5 and K2O applied to the field to produce 180 bushels of corn per acre is given in Figure 1. The 20% of chicken litter make up 4910 lbs/acre. This is the amount of chicken litter that will be removed from the fields and used in the future scenario biomass power plant for each MWhr of electricity produced. Since this amount is applied to the field, power production (or power and steam production) is done using coal.

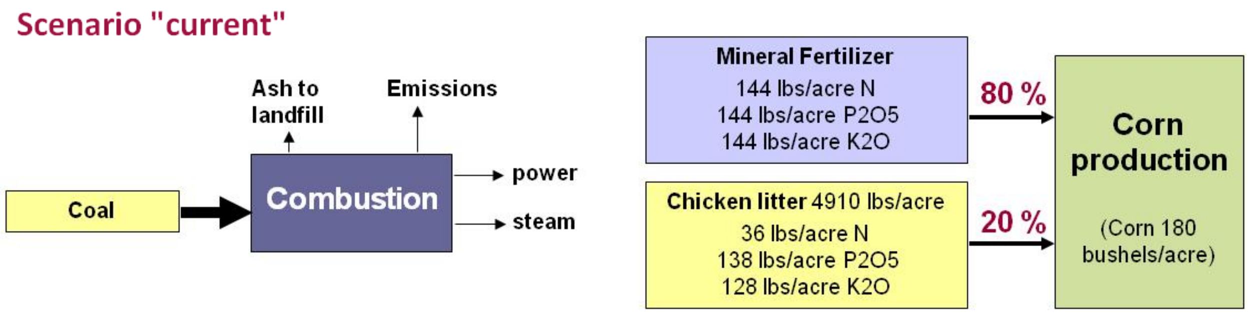


Figure 1: Settings for the current scenario

Modeling the agricultural corn production in the current scenario, an erosion rate of 30 tons per hectare and year (= 12.5 tons per acre and year, data from Bill Achor, LandStudies) is estimated, from which 50% reaches the Chesapeake Bay (estimated from the share "area IMPORTED / EXPORTED" by Bill Achor"), which means that 15 tons per year enter into the Chesapeake Bay watershed. The following values have been the basis for the calculation for soil erosion.

- 0.0003 lbs P2O5 / lbs eroded soil [Source:, Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH and LBP University of Stuttgart, January 2007.
- 0.007 lbs NO3 / lbs eroded soil [Source: Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH and LBP University of Stuttgart, January 2007.
- 0.012 lbs N organic / lbs eroded soil [Source: Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH and LBP University of Stuttgart, January 2007.
- 0.15 lbs C organic / lbs eroded soil [Source: Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH and LBP University of Stuttgart, January 2007.

In the future scenario, fertilization in corn production is done using only mineral fertilizer. The "saved" chicken litter (4910 lbs/acre) is transferred to a combustion unit, thus providing electric power or electric power and steam production (Figure 2).

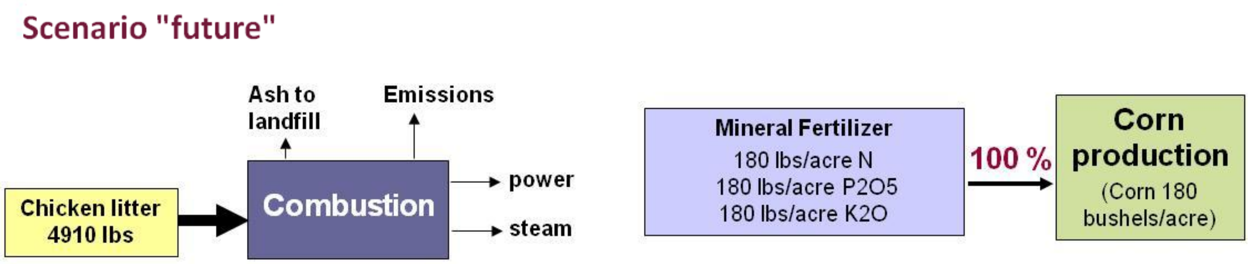


Figure 2: Settings for the future scenario

Modeling the agricultural corn production in the future scenario, again an erosion of 30 tons per year is estimated, from which 50% reaches the bay, which means that 15 tons per year enter the waterway. The following values have been the basis for the calculation of soil erosion in the future scenario, where no chicken litter is applied to the field.

- 0.00015 lbs P_2O_5 / lbs eroded soil [Source: Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH and LBP University of Stuttgart, January 2007.
- 0.0035lbs NO_3 / lbs eroded soil [Source: Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH and LBP University of Stuttgart, January 2007.0.006 lbs N organic / lbs eroded soil [Source: Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH and LBP University of Stuttgart, January 2007.
- 0.075 lbs C organic / lbs eroded soil [Source: Software and data base for Life Cycle Engineering, PE INTERNATIONAL GmbH and LBP University of Stuttgart, January 2007.

In total, for each scenario two different options are calculated: one is the power production only, which means that the thermal energy produced cannot be used and is "wasted" as steam, the second one is the production and use of power and steam at the same time. Table 1 gives the overview on what was compared in the study.

Table 1: Overview on the scenarios/options investigated

	Current scenario	Current scenario	Future scenario	Future scenario
Input Field	**Chicken litter** & mineral fertilizer	**Chicken litter** & mineral fertilizer	Mineral fertilizer	Mineral fertilizer
Output Field	Corn	Corn	Corn	Corn
Input power plant	Coal	Coal	**Chicken litter**	**Chicken litter**
Output	power only	Combined heat & power	power only	Combined heat & power

As an example, Figure 3 shows the model set up for the chicken litter combustion in the future scenario.

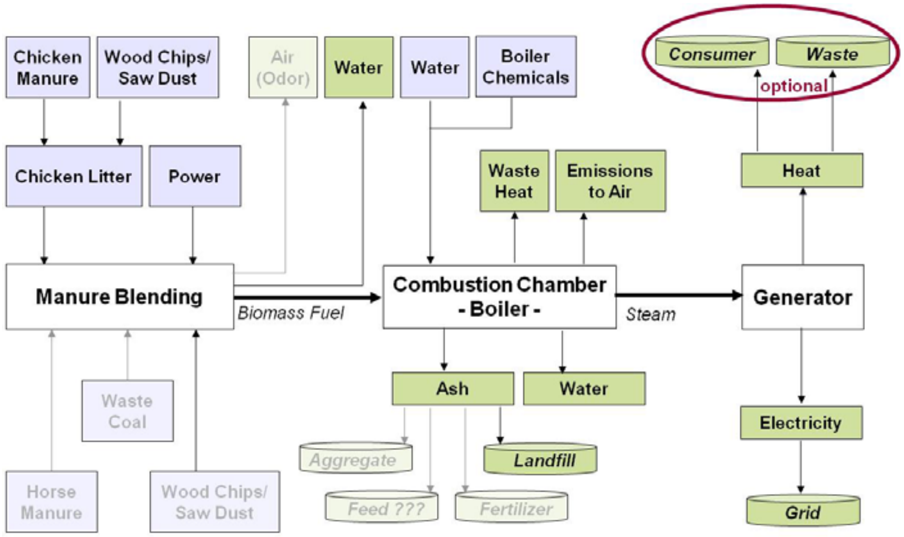


Figure 3: Model set up for the future scenario

Parameter Settings

A prerequisite for the comparison of the different scenarios and options is the application of the same functional units. This is set to an output of 1 MWh power in the power plant and to an output of 6493 lbs corn from the field (Table 2).

Based on information provided by the United States Department of Energy, Office for electricity and energy reliability, heat fuel utilization efficiency in the model is set to 70 % .(Distributed Energy program) [http://www.eere.energy.gov/de/chp/chp_applications/application_basics.html]:

> *"CHP reduces energy costs and emissions by using energy resources more efficiently. In conventional conversion of fuel to electricity, over two-thirds of the energy input is discarded as heat to the environment and not used for productive purposes. CHP makes greater use of fuel inputs by utilizing the discarded heat with system potential efficiencies from 60 to 80."*

Table 2: Overview on the settings and on the functional units as basis for the life Cycle Assessment

	Output:	power only		Combined heat & power	
	Unit	Current scenario	Future scenario	Current scenario	Future scenario
Power plant settings					
Power production (Functional unit)	[MWh]	**1**	**1**	**1**	**1**
Usable thermal energy * (from PP waste heat)	[MWh]	0	0	1.52	2.03
Total usable energy produced	[MWh]	1	1	2,52	3,03
Overall efficiency of the complete energy chain	[%]	31.9	31.7	68.2	67.2
Power plant efficiency	[%]	34.0	33.0		
Heating value of chicken litter (lower calorific value)	[BTU/lbs]	4637	4637	4637	4637
Fuel utilization efficiency	[%]			70.0	70.0
Chicken litter in power plant	[lbs]		3205		3205
Agrarian settings					
Corn produced (Functional unit)	[lbs]	**6493**	**6493**	**6493**	**6493**
Chicken litter to field	[lbs]	3205		3205	
Acreage needed	[acre]	0.65	0.65	0.65	0.65

* The usable thermal energy is handled as a beneficiation in the system, it substitutes thermal energy from coal.

The overall efficiency of the complete energy chain is more than twice as high, when combined heat and power is produced and used.

Although the functional unit for the power plant is the same in the two scenarios and the two options (1 MWh) it is not possible to compare all four variants at the same time, since in the option "Combined heat and power" an additional output of usable thermal energy is produced. On the one hand a comparison is valid between current and future scenario within the option "power only", and on the other hand between the current and future scenario within the option "combined heat and power". In the following, the results are therefore presented separately for the two options.

Results

In the following, the results are displayed for the two options separately. The left figure shows the results for the current and future scenario within the option "power only". On the right side the results for the current and future scenario within the option "combined heat and power" are displayed.

The **energy demand** is a valuable measuring unit for the consumption of resources in Life Cycle Assessment studies. Figure 4 gives the results on non-renewable (= fossil) energy demand. Additionally – here the renewable energy incorporation is shown, since the produced corn and the chicken litter has energy incorporated. The main results are:

- The non-renewable energy demand is the energy demand for corn production and the power plant.
- The non-renewable energy demand is lower (around one third in the option "Power only" and almost zero in the option "Combined heat and power") for the future scenario compared to the current scenario. This is due to the fact, that fossil coal is substituted by chicken litter as the energy source.

- Option “Power only”: In the future scenario 96 % of the non-renewable energy demand is used for corn production. Only 4 % of the fossil fuel demand is needed to run the power plant
- The renewable energy incorporation is made up of energy incorporated in corn and in chicken litter and is almost the same in both scenarios.

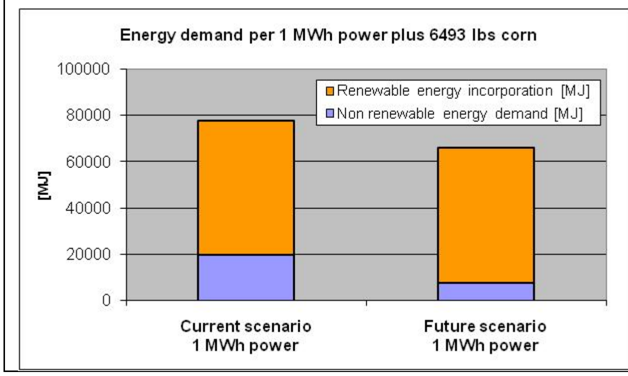
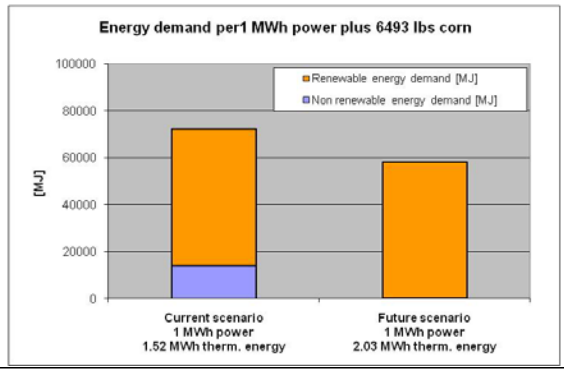
Option: Power only	**Option: Combined Heat and Power**
	

Figure 4: Renewable energy demand per 1 MWh power output and 6493 lbs corn output

The results on **Global Warming Potential** (GWP) are shown in Figure 5. Overall, a reduction of GWP is achieved when coal is substituted by chicken litter in the power plant.

- Option “Power only”: The GWP associated with the power plant (current scenario) is 1250 kg and 500 kg for the future scenario. It is lower due to the fact, that some of the CO2 emitted from incineration was bound before in the chicken litter.
- The CO2 emissions for the corn production are set off against the incorporated CO2 in corn.
- Option “Combined Heat and Power”: Due to the overall efficiency of the complete energy chain, the GWP is slightly negative under the assumptions made.
- Please note: The CO2 emissions from chicken litter applied on the field in the current scenario is **not** accounted for due to incomplete data.

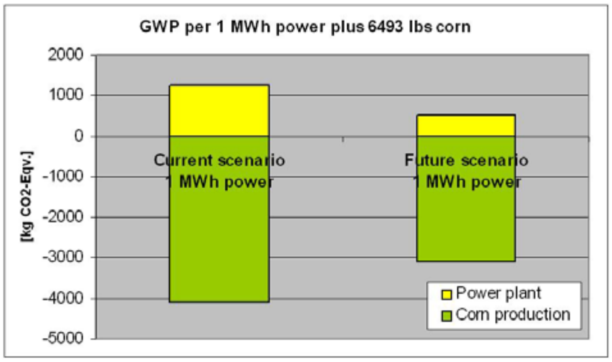
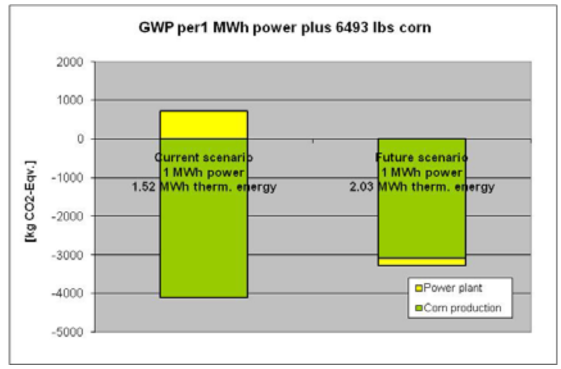
Option: Power only	Option: Combined Heat and Power
	

Figure 5: Global warming potential per 1 MWh power output and 6493 lbs corn output

The results on **Ozone Depletion Potential** (ODP) are given in Figure 6. A switch from the current scenario to the future scenario results into a slight increase of the impact category ODP.

- Corn production is responsible for almost all ODP. The ODP caused by the power plant is quite similar.
- The reason for the slight increase in ODP is from the halogen organic emissions. NPK fertilizer production is used in a higher amount in the future scenario to replace the chicken litter which is incinerated.
- Option “Power only” and option “Combined Heat and Power” show same tendencies.

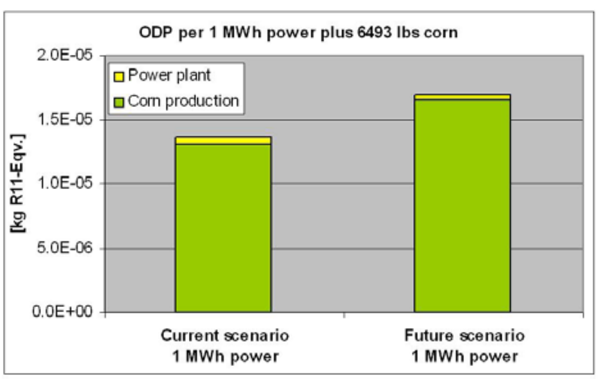
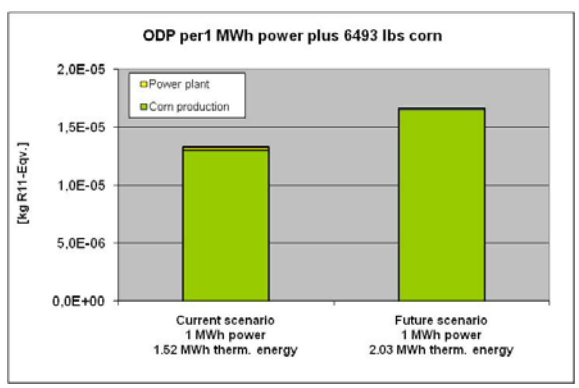
Option: Power only	Option: Combined Heat and Power
	

Figure 6: Ozone depletion potential per 1 MWh power output and 6493 lbs corn output

Figure 7 shows the results on the **Acidification Potential (AP)** between the two scenarios. While the impact to AP from corn production is similar between the scenarios, an increase of this impact deriving from the power plant is visible in the future scenario.

- The high chlorine content in the chicken litter being burned in the future scenario contributes as hydrogen chloride to the Acidification Potential.

- Further contributors are sulfur dioxide and nitrogen oxides.
- In the model, only the coal power plant is equipped with a desulphurization unit, whereas the biomass combustion is not. To greatly reduce the AP, the biomass combustion unit should be equipped with a desulphurization unit as well. When so equipped, the release of Acidification Potential emissions will be controlled to the same extent of the coal plant, thus this parameter will be neutral in the proposed state.

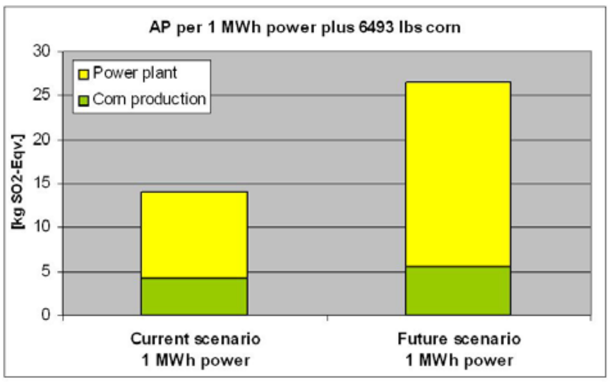
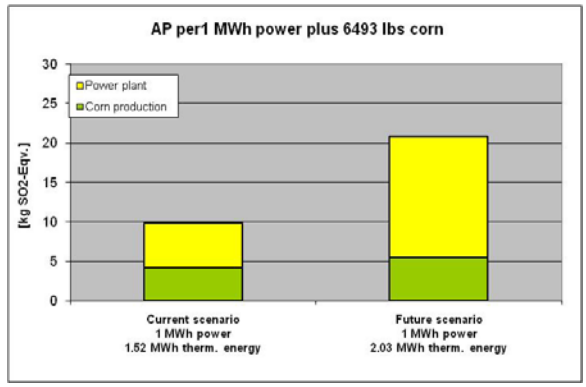
<table>
<tr><th>Option: Power only</th><th>Option: Combined Heat and Power</th></tr>
<tr><td>
</td><td>
</td></tr>
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Figure 7: Acidification potential per 1 MWh power output and 6493 lbs corn output: Note that when the future biomass power plant is equipped with appropriate pollution control equipment this result will be neutralized.

Looking at the **Eutrophication Potential** (EP) (Figure 8), almost 100 % of the EP derives from the agricultural process. The power plant shows almost no effect on EP.

- Nitrate, phosphate and organic bound nitrogen emissions to water mostly contribute to the EP.
- Our assumption is that the ash generated in the biomass fired power plant will be disposed of in a contained landfill.
- As work progresses, beneficial use of the ash is anticipated, when identified, this alternative use will be modeled for EP.
- In the current scenario, these emissions are almost twice as high when compared to the future scenario, due to the chicken litter used as fertilizer and the higher nutrient intake to the bay via erosion.

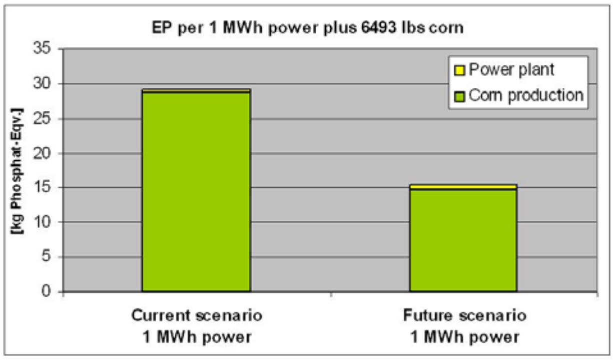
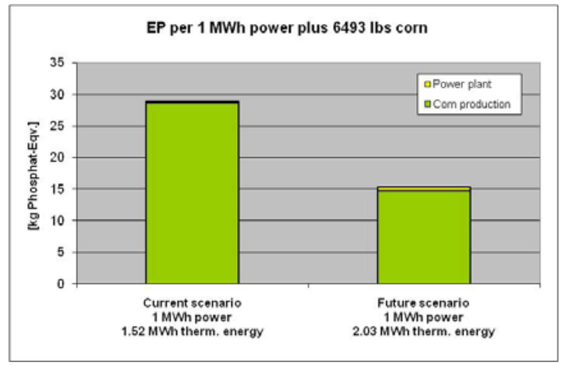
Option: Power only	**Option: Combined Heat and Power**
	

Figure 8: Eutrophication potential per 1 MWh power output and 6493 lbs corn output

The overall **Photochemical Ozone Creation Potential (POCP)** (Figure 9) is increased in the future scenario.

- Slight increase of POCP due to the agricultural process in the future scenario.
- Major increase due to combustion. CO emissions are higher in the future scenario compared to the current scenario.
- Nitrogen oxide emissions are twice as high in future scenario compared to current scenario.
- The power plant must be equipped with appropriate stack controls so that the Nitrogen oxide emissions are controlled to within the prescribed limits.

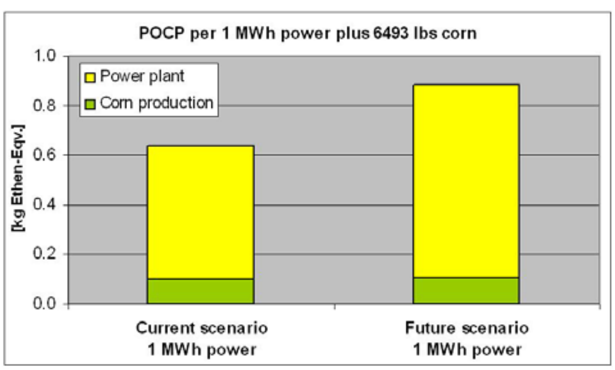
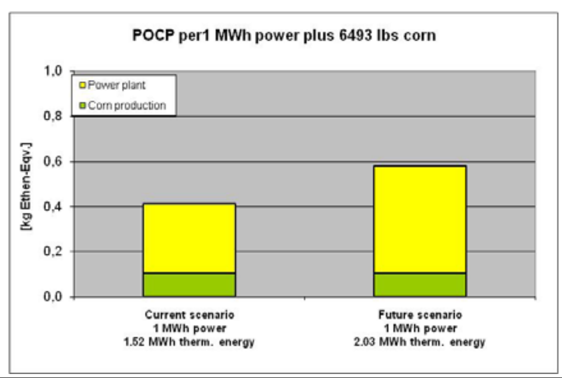
Option: Power only	**Option: Combined Heat and Power**
	

Figure 9: Photochemical Ozone Creation Potential per 1 MWh power output and 6493 lbs corn output

Conclusions

The switch from current scenario to future scenario will clearly lower the non-renewable (= fossil) energy demand and the Eutrophication Potential, which are the most demanding goals in the area under consideration (Table 3). Other impacts slightly increase – but further optimization potential could be identified.

Table 3: Overview on the results of the Life Cycle Assessment

Option: Power only

Impact	Future scenario compared to Current scenario	
Energy demand	↓	- 15 %
GWP*	→	+ 10 %
ODP	↑	+ 20 %
AP	↑	+ 47 %
EP	↓	- 47 %
POCP	↑	+ 39 %

Option: Combined Heat and Power

Impact	Future scenario compared to Current scenario	
Energy demand	↓	- 19 %
GWP*	→	+ 3 %
ODP	↑	+ 24 %
AP	↑	+ 111 %
EP	↓	- 47 %
POCP	↑	+ 41 %

*The CO2 emissions from chicken litter applied on field in the current scenario is so far **not** accounted for in the study as data is unavailable.

All impacts are lowered if combined power and thermal energy is produced and used instead of “power only” which means that the “Chicken litter combustion plant” should be located next to a user of thermal energy, which then can be sold and save up impacts caused by thermal energy from fossil fuels.
The share of transportation processes (for e.g. the chicken litter) compared to the overall impacts is rather low.
The Global Warming Potential will definitely decrease in the future scenario, when the CO2 emissions from chicken litter applied on the field are considered in the current scenario.
The biomass power plant has to be equipped with a desulphurization unit (scrubber) to lower the acidification potential
Further optimization potential is seen in the agricultural processes.

Appendix 3 – Nutrient Credit Calculations

BMP	Nitrogen credits	Phosphorus credits	Application of Poultry Manure
10 MW Combustion Facility - Utilizing Poultry Litter from Lancaster County	**824,098**	**109,494**	Assumes that 63,875 tons of poultry litter that is currently applied to conventional tillage row crops in Lancaster County will be replaced with fertilizer to achieve the proper nitrogen need for crops through a nutrient management plan for nitrogen.
	units for credits are lbs per year		63,875

Calculations:

10 MW Combustion Facility - Utilizing Poultry Litter from Lancaster County	Nitrogen	
total nitrogen in manure applied to crops	2,880,763	(63,875 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	432,114	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	2,448,648	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	1,181,840	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	432,114	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	864,229	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	432,114	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	208,560	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	973,280	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	57,615	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	915,665	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	824,098	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	121,660	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	109,494	assumes a 1:1 trading ratio and a 10 percent reserve ratio

ASSUMPTIONS:

[1] *Based on a poultry litter analysis provided by Wenger Feeds and analyzed by Midwest Laboratories, Inc. Sample Id BV-H6 1-7-05*

[2] *Percentages and factors based on guidance from PA DEP*

[3] *Delivery ratios were averaged across watersheds in Lancaster County*

BMP	Nitrogen credits	Phosphorus credits	Application of Poultry Manure
7 MW Combustion Facility - Utilizing Poultry Litter from Lancaster County	**576,875**	**76,647**	Assumes that 44,713 tons of poultry litter that is currently applied to conventional tillage row crops in Lancaster County will be replaced with fertilizer to achieve the proper nitrogen need for crops through a nutrient management plan for nitrogen.
	units for credits are lbs per year		44,713

Calculations:

7 MW Combustion Facility - Utilizing Poultry Litter from Lancaster County	Nitrogen	
total nitrogen in manure applied to crops	2,016,556	(44,713 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	302,483	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	1,714,073	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	827,297	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	302,483	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	604,967	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	302,483	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	145,994	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	681,304	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	40,331	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	640,973	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	576,875	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	85,163	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	76,647	assumes a 1:1 trading ratio and a 10 percent reserve ratio

ASSUMPTIONS:

[1] *Based on a poultry litter analysis provided by Wenger Feeds and analyzed by Midwest Laboratories, Inc. Sample Id BV-H6 1-7-05*

[2] *Percentages and factors based on guidance from PA DEP*

[3] *Delivery ratios were averaged across watersheds in Lancaster County*

BMP	Nitrogen credits	Phosphorus credits	Application of Poultry Manure
5 MW Combustion Facility - Utilizing Poultry Litter from Lancaster County	**412,056**	**54,748**	Assumes that 31,938 tons of poultry litter that is currently applied to conventional tillage row crops in Lancaster County will be replaced with fertilizer to achieve the proper nitrogen need for crops through a nutrient management plan for nitrogen.
	units for credits are lbs per year		31,938

Calculations:

5 MW Combustion Facility - Utilizing Poultry Litter from Lancaster County	Nitrogen	
total nitrogen in manure applied to crops	1,440,404	(31,938 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	216,061	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	1,224,343	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	590,929	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	216,061	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	432,121	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	216,061	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	104,282	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	486,648	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	28,808	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	457,840	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	412,056	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	60,831	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	54,748	assumes a 1:1 trading ratio and a 10 percent reserve ratio

ASSUMPTIONS:

[1] *Based on a poultry litter analysis provided by Wenger Feeds and analyzed by Midwest Laboratories, Inc. Sample Id BV-H6 1-7-05*

[2] *Percentages and factors based on guidance from PA DEP*

[3] *Delivery ratios were averaged across watersheds in Lancaster County*

BMP	Nitrogen credits	Phosphorus credits	Application of Poultry Manure
2 MW Combustion Facility - Utilizing Poultry Litter from Lancaster County	**164,820**	**21,899**	Assumes that 12,775 tons of poultry litter that is currently applied to conventional tillage row crops in Lancaster County will be replaced with fertilizer to achieve the proper nitrogen need for crops through a nutrient management plan for nitrogen.

units for credits are lbs per year

12,775

Calculations:

2 MW Combustion Facility - Utilizing Poultry Litter from Lancaster County	Nitrogen	
total nitrogen in manure applied to crops	576,153	(12,775 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	86,423	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	489,730	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	236,368	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	86,423	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	172,846	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	86,423	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	41,712	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	194,656	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	11,523	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	183,133	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	164,820	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	24,332	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	21,899	assumes a 1:1 trading ratio and a 10 percent reserve ratio

ASSUMPTIONS:

[1] *Based on a poultry litter analysis provided by Wenger Feeds and analyzed by Midwest Laboratories, Inc. Sample Id BV-H6 1-7-05*

[2] *Percentages and factors based on guidance from PA DEP*

[3] *Delivery ratios were averaged across watersheds in Lancaster County*

BMP	Nitrogen credits	Phosphorus credits	Application of Poultry Manure
10 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties	**805,981**	**107,229**	Assumes that 63,875 tons of poultry litter that is currently applied to conventional tillage row crops in the counties listed below will be replaced with fertilizer to achieve the proper nitrogen need for crops through a nutrient management plan for nitrogen.

units for credits are lbs per year

County	***Source Percentage***		
Lancaster	40%	25,550	63,875
Snyder	15%	9,581	
Juniata	15%	9,581	
Union	5%	3,194	
Perry	10%	6,388	
Schuylkill	5%	3,194	
Lebanon	10%	6,388	

Calculations: **Nitrogen**

10 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Lancaster County		
total nitrogen in manure applied to crops	1,152,305	(25,550 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	172,846	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	979,459	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	472,736	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	172,846	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	345,692	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	172,846	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	83,424	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	389,312	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	23,046	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay
		assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	366,266	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	329,639	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	48,664	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	43,798	assumes a 1:1 trading ratio and a 10 percent reserve ratio

10 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Snyder County		
total nitrogen in manure applied to crops	432,114	(9,581 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	64,817	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	367,297	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	174,650	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	64,817	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	129,634	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	64,817	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	30,821	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	143,829	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	8,642	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay
		assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	135,187	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	121,668	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	17,979	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	16,181	assumes a 1:1 trading ratio and a 10 percent reserve ratio

10 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Juniata County		
total nitrogen in manure applied to crops	432,114	(9,581 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	64,817	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	367,297	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	164,880	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	64,817	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	129,634	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	64,817	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	29,096	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	135,783	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	8,642	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	127,141	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	114,427	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	16,973	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	15,276	assumes a 1:1 trading ratio and a 10 percent reserve ratio

10 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Union County		
total nitrogen in manure applied to crops	144,038	(3,194 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	21,606	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	122,432	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	57,806	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	21,606	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	43,211	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	21,606	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	10,201	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	47,605	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	2,881	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	44,725	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	40,252	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	5,951	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	5,356	assumes a 1:1 trading ratio and a 10 percent reserve ratio

10 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Perry County

total nitrogen in manure applied to crops	288,076	(6,388 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	43,211	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	244,865	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	114,260	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	43,211	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	86,423	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	43,211	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	20,164	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	94,097	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	5,762	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	88,335	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	79,501	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	11,762	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	10,586	assumes a 1:1 trading ratio and a 10 percent reserve ratio

10 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Schuylkill County

total nitrogen in manure applied to crops	144,038	(3,194 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	21,606	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	122,432	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	57,145	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	21,606	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	43,211	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	21,606	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	10,084	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	47,061	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	2,881	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	44,180	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	39,762	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	5,883	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	5,294	assumes a 1:1 trading ratio and a 10 percent reserve ratio

10 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Lebanon County		
total nitrogen in manure applied to crops	288,076	(6,388 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	43,211	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	244,865	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	115,919	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	43,211	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	86,423	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	43,211	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	20,456	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	95,463	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	5,762	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay
		assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	89,701	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	80,731	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	11,933	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	10,740	assumes a 1:1 trading ratio and a 10 percent reserve ratio

[1] *Based on a poultry litter analysis provided by Wenger Feeds and analyzed by Midwest Laboratories, Inc. Sample Id BV-H6 1-7-05*

[2] *Percentages and factors based on guidance from PA DEP*

[3] *Delivery ratios were averaged across watersheds in Lancaster County*

BMP	Nitrogen credits	Phosphorus credits	Application of Poultry Manure
7 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties	**564,193**	**75,061**	Assumes that 44,713 tons of poultry litter that is currently applied to conventional tillage row crops in the counties listed below will be replaced with fertilizer to achieve the proper nitrogen need for crops through a nutrient management plan for nitrogen.

units for credits are lbs per year

County	*Source Percentage*		
Lancaster	40%	17,885	44,713
Snyder	15%	6,707	
Juniata	15%	6,707	
Union	5%	2,236	
Perry	10%	4,471	
Schuylkill	5%	2,236	
Lebanon	10%	4,471	

Calculations: **Nitrogen**

7 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Lancaster County		
total nitrogen in manure applied to crops	806,623	(17,885 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	120,993	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	685,629	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	330,919	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	120,993	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	241,987	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	120,993	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	58,397	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	272,521	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	16,132	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	256,389	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	230,750	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	34,065	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	30,659	assumes a 1:1 trading ratio and a 10 percent reserve ratio

7 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Snyder County		
total nitrogen in manure applied to crops	302,483	(6,707 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	45,373	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	257,111	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	122,256	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	45,373	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	90,745	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	45,373	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	21,575	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	100,682	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	6,050	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	94,632	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	85,169	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	12,585	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	11,327	assumes a 1:1 trading ratio and a 10 percent reserve ratio

7 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Juniata County

total nitrogen in manure applied to crops	302,483	(6,707 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	45,373	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	257,111	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	115,417	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	45,373	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	90,745	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	45,373	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	20,368	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	95,049	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	6,050	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	89,000	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	80,100	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	11,881	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	10,693	assumes a 1:1 trading ratio and a 10 percent reserve ratio

7 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Union County

total nitrogen in manure applied to crops	100,828	(2,236 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	15,124	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	85,704	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	40,465	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	15,124	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	30,248	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	15,124	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	7,141	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	33,324	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	2,017	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	31,308	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	28,177	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	4,166	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	3,749	assumes a 1:1 trading ratio and a 10 percent reserve ratio

7 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Perry County		
total nitrogen in manure applied to crops	201,656	(4,471 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	30,248	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	171,407	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	79,983	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	30,248	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	60,497	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	30,248	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	14,115	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	65,868	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	4,033	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	61,835	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	55,652	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	8,234	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	7,410	assumes a 1:1 trading ratio and a 10 percent reserve ratio

7 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Schuylkill County		
total nitrogen in manure applied to crops	100,828	(2,236 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	15,124	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	85,704	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	40,002	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	15,124	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	30,248	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	15,124	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	7,059	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	32,943	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	2,017	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	30,926	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	27,834	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	4,118	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	3,706	assumes a 1:1 trading ratio and a 10 percent reserve ratio

7 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Lebanon County

total nitrogen in manure applied to crops	201,656	(4,471 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	30,248	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment [1]	171,407	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	81,144	edge of segment ratio [2] and delivery ratio [3]
replacement fertilizer nitrogen needed	30,248	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	60,497	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	30,248	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	14,320	edge of segment ratio [2] and delivery ratio [3]
nitrogen load reduction from fields	66,825	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	4,033	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	62,792	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	56,512	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	8,353	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	7,518	assumes a 1:1 trading ratio and a 10 percent reserve ratio

[1] *Based on a poultry litter analysis provided by Wenger Feeds and analyzed by Midwest Laboratories, Inc. Sample Id BV-H6 1-7-05*
[2] *Percentages and factors based on guidance from PA DEP*
[3] *Delivery ratios were averaged across watersheds in Lancaster County*

BMP	Nitrogen credits	Phosphorus credits	Application of Poultry Manure
5 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties	**402,997**	**53,616**	Assumes that 31,938 tons of poultry litter that is currently applied to conventional tillage row crops in the counties listed below will be replaced with fertilizer to achieve the proper nitrogen need for crops through a nutrient management plan for nitrogen.

units for credits are lbs per year

County	Source Percentage		
Lancaster	40%	12,775	31,938
Snyder	15%	4,791	
Juniata	15%	4,791	
Union	5%	1,597	
Perry	10%	3,194	
Schuylkill	5%	1,597	
Lebanon	10%	3,194	

Calculations: **Nitrogen**

5 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Lancaster County		
total nitrogen in manure applied to crops	576,162	(12,775 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	86,424	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	489,737	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	236,372	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	86,424	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	172,848	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	86,424	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	41,713	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	194,659	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	11,523	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	183,136	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	164,822	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	24,332	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	21,899	assumes a 1:1 trading ratio and a 10 percent reserve ratio

5 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Snyder County		
total nitrogen in manure applied to crops	216,061	(4,791 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	32,409	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	183,651	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	87,326	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	32,409	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	64,818	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	32,409	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	15,411	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	71,916	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	4,321	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	67,595	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	60,835	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	8,989	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	8,091	assumes a 1:1 trading ratio and a 10 percent reserve ratio

5 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Juniata County		
total nitrogen in manure applied to crops	216,061	(4,791 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	32,409	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment [1]	183,651	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	82,441	edge of segment ratio [2] and delivery ratio [3]
replacement fertilizer nitrogen needed	32,409	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	64,818	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	32,409	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	14,548	edge of segment ratio [2] and delivery ratio [3]
nitrogen load reduction from fields	67,893	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	4,321	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	63,572	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	57,214	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	8,487	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	7,638	assumes a 1:1 trading ratio and a 10 percent reserve ratio

5 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Union County		
total nitrogen in manure applied to crops	72,020	(1,597 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	10,803	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment [1]	61,217	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	28,904	edge of segment ratio [2] and delivery ratio [3]
replacement fertilizer nitrogen needed	10,803	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	21,606	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	10,803	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	5,101	edge of segment ratio [2] and delivery ratio [3]
nitrogen load reduction from fields	23,803	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	1,440	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	22,363	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	20,126	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	2,975	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	2,678	assumes a 1:1 trading ratio and a 10 percent reserve ratio

5 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Perry County

total nitrogen in manure applied to crops	144,040	(3,194 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	21,606	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	122,434	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	57,131	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	21,606	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	43,212	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	21,606	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	10,082	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	47,049	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	2,881	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	44,168	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	39,751	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	5,881	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	5,293	assumes a 1:1 trading ratio and a 10 percent reserve ratio

5 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Schuylkill County

total nitrogen in manure applied to crops	72,020	(1,597 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	10,803	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	61,217	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	28,573	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	10,803	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	21,606	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	10,803	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	5,042	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	23,531	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	1,440	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	22,090	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	19,881	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	2,941	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	2,647	assumes a 1:1 trading ratio and a 10 percent reserve ratio

5 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Lebanon County

total nitrogen in manure applied to crops	144,040	(3,194 tons x 45.1 lbs TN per ton of poultry litter)[1]
manure nitrogen taken up by crops	21,606	15 percent of manure nitrogen available and used by crops[2]
manure nitrogen lost to environment[1]	122,434	85 percent of manure nitrogen lost to environment[2]
current manure nitrogen loading (EOS and DR)	57,960	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	21,606	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	43,212	50 percent nitrogen uptake by plants from fertilizer[2]
fertilizer nitrogen lost to environment	21,606	50 percent nitrogen loss from fertilizer applications[2]
replacement fertilizer nitrogen loading (EOS and DR)	10,228	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	47,732	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	2,881	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	44,851	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	40,366	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	5,967	calculated by dividing the net nitrogen load reductions from the fields by 8[2]
phosphorus nutrient credits (lbs per year)	5,370	assumes a 1:1 trading ratio and a 10 percent reserve ratio

[1] *Based on a poultry litter analysis provided by Wenger Feeds and analyzed by Midwest Laboratories, Inc. Sample Id BV-H6 1-7-05*
[2] *Percentages and factors based on guidance from PA DEP*
[3] *Delivery ratios were averaged across watersheds in Lancaster County*

BMP	Nitrogen credits	Phosphorus credits	Application of Poultry Manure
2 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties	**161,196**	**21,446**	Assumes that 12,775 tons of poultry litter that is currently applied to conventional tillage row crops in the counties listed below will be replaced with fertilizer to achieve the proper nitrogen need for crops through a nutrient management plan for nitrogen.

units for credits are lbs per year

County	Source Percentage		
Lancaster	40%	5,110	12,775
Snyder	15%	1,916	
Juniata	15%	1,916	
Union	5%	639	
Perry	10%	1,278	
Schuylkill	5%	639	
Lebanon	10%	1,278	

Calculations: **Nitrogen**

2 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Lancaster County

total nitrogen in manure applied to crops	230,461	(5,110 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	34,569	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	195,892	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	94,547	edge of segment ratio[2] and delivery ratio [3]
replacement fertilizer nitrogen needed	34,569	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	69,138	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	34,569	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	16,685	edge of segment ratio[2] and delivery ratio [3]
nitrogen load reduction from fields	77,862	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	4,609	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	73,253	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	65,928	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	9,733	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	8,760	assumes a 1:1 trading ratio and a 10 percent reserve ratio

2 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Snyder County

total nitrogen in manure applied to crops	86,423	(1,916 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	12,963	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	73,459	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	34,930	edge of segment ratio[2] and delivery ratio [3]
replacement fertilizer nitrogen needed	12,963	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	25,927	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	12,963	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	6,164	edge of segment ratio[2] and delivery ratio [3]
nitrogen load reduction from fields	28,766	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	1,728	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	27,037	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	24,334	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	3,596	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	3,236	assumes a 1:1 trading ratio and a 10 percent reserve ratio

2 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Juniata County		
total nitrogen in manure applied to crops	86,423	(1,916 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	12,963	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment [1]	73,459	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	32,976	edge of segment ratio [2] and delivery ratio [3]
replacement fertilizer nitrogen needed	12,963	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	25,927	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	12,963	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	5,819	edge of segment ratio [2] and delivery ratio [3]
nitrogen load reduction from fields	27,157	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	1,728	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	25,428	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	22,885	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	3,395	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	3,055	assumes a 1:1 trading ratio and a 10 percent reserve ratio

2 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Union County		
total nitrogen in manure applied to crops	28,808	(639 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	4,321	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment [1]	24,486	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	11,561	edge of segment ratio [2] and delivery ratio [3]
replacement fertilizer nitrogen needed	4,321	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	8,642	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	4,321	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	2,040	edge of segment ratio [2] and delivery ratio [3]
nitrogen load reduction from fields	9,521	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	576	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	8,945	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	8,050	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	1,190	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	1,071	assumes a 1:1 trading ratio and a 10 percent reserve ratio

2 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Perry County

total nitrogen in manure applied to crops	57,615	(1,278 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	8,642	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment [1]	48,973	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	22,852	edge of segment ratio [2] and delivery ratio [3]
replacement fertilizer nitrogen needed	8,642	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	17,285	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	8,642	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	4,033	edge of segment ratio [2] and delivery ratio [3]
nitrogen load reduction from fields	18,819	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	1,152	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	17,667	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	15,900	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	2,352	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	2,117	assumes a 1:1 trading ratio and a 10 percent reserve ratio

2 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Schuylkill County

total nitrogen in manure applied to crops	28,808	(639 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	4,321	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment [1]	24,486	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	11,429	edge of segment ratio [2] and delivery ratio [3]
replacement fertilizer nitrogen needed	4,321	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	8,642	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	4,321	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	2,017	edge of segment ratio [2] and delivery ratio [3]
nitrogen load reduction from fields	9,412	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	576	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	8,836	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	7,952	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	1,177	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	1,059	assumes a 1:1 trading ratio and a 10 percent reserve ratio

2 MW Combustion Facility - Utilizing Poultry Litter from Multiple Counties - Lebanon County		
total nitrogen in manure applied to crops	57,615	(1,278 tons x 45.1 lbs TN per ton of poultry litter) [1]
manure nitrogen taken up by crops	8,642	15 percent of manure nitrogen available and used by crops [2]
manure nitrogen lost to environment[1]	48,973	85 percent of manure nitrogen lost to environment [2]
current manure nitrogen loading (EOS and DR)	23,184	edge of segment ratio[2] and delivery ratio[3]
replacement fertilizer nitrogen needed	8,642	amount of fertilizer nitrogen uptake needed to maintain yield
total nitrogen in replacement fertilizer	17,285	50 percent nitrogen uptake by plants from fertilizer [2]
fertilizer nitrogen lost to environment	8,642	50 percent nitrogen loss from fertilizer applications [2]
replacement fertilizer nitrogen loading (EOS and DR)	4,091	edge of segment ratio[2] and delivery ratio[3]
nitrogen load reduction from fields	19,093	current loading minus fertilizer replacement loading
nitrogen loss from energy combustion facility	1,152	assumes that 2% of the nitrogen in the poultry litter ends up as an airborne NO_x load to the Bay
		assumes that the nitrogen in the ash from the combustion facility is land filled
net nitrogen load reduction	17,940	nitrogen load reduction from fields minus loads from combustion facility
nitrogen nutrient credits (lbs per year)	16,146	assumes a 1:1 trading ratio and a 10 percent reserve ratio
gross phosphorus nutrient credits (lbs per year)	2,387	calculated by dividing the net nitrogen load reductions from the fields by 8 [2]
phosphorus nutrient credits (lbs per year)	2,148	assumes a 1:1 trading ratio and a 10 percent reserve ratio

[1] *Based on a poultry litter analysis provided by Wenger Feeds and analyzed by Midwest Laboratories, Inc. Sample Id BV-H6 1-7-05*
[2] *Percentages and factors based on guidance from PA DEP*
[3] *Delivery ratios were averaged across watersheds in Lancaster County*

Factor	Nitrogen		Notes
Delivery Factor	0.965		Lancaster County - average across county watersheds
	0.951		Snyder County - average across county watersheds
	0.898		Juniata County - average across county watersheds
	0.944		Union County - average across county watersheds
	0.933		Perry County - average across county watersheds
	0.934		Schuylkill County - average across county watersheds
	0.947		Lebanon County - average across county watersheds
Reserve Ratio	10%		assumption
Trading Ratio	1:1		assumption - needs to be negotiated
Edge of Segment Ratio			
Conventional Till	50%		assumed edge of segment ratio from PA DEP for manure trades