ABSTRACT

This paper explores the market potential for thermally dried biosolids generated by the Exeter Township Wastewater Treatment Plant (WWTP) in terms of the 1) major energy markets that are appropriate for use, 2) product specifications for each of the energy markets, and 3) potential revenue that could be generated in the energy markets.

Potential consumers of Exeter’s biosolids as a fuel source include cement and lime kilns, energy generation facilities, and large facilities requiring substantial fuel to heat during the winter months (large boilers or furnaces). These entities were contacted and interviewed to gauge their receptivity to this product and their estimation of its value. Receptivity was generally high and value estimations were generally in line with similar products.

Product value is measured by the market forces of demand and adherence to market specifications. For example, the existing energy market demand for biofuels is not fully developed because the level of support from government incentives for burning biofuels is not established. This is an example of market factors that define the value of the product. Market specifications require adherence to sufficient energy values and air emission control initiatives. Table 1 depicts the values anticipated as well as product specifications from the energy market.

Most potential customers requested demonstrations of the product before a commitment is made to use the product. Trials are an important tool in marketing as they will show the effectiveness of the product in terms of energy value and the ease to handle/store fuel for the energy market.

Table 1. Product value and specifications from different markets.

<table>
<thead>
<tr>
<th>Value</th>
<th>Market</th>
<th>Product Specifications</th>
<th>Relative Potential for Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Energy</td>
<td>High Btu / energy value</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Significant production / quantity</td>
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</tbody>
</table>

KEYWORDS

Biosolids, energy, fuel, coal, market, renewable energy credits.
INTRODUCTION

Exeter Township (Berks County, Pennsylvania) has adopted a proven process for manufacturing a valuable product from wastewater treatment plant (WWTP) residuals. They recently upgraded their solids handling system by installing a biosolids thermal dryer that can produce a useful, eco-friendly fuel, while concurrently providing a service of alternative energy production.

The Exeter Township WWTP utilizes an anaerobic digestion process with centrifuges for dewatering (Photo 1) followed by thermal drying, producing an exceptional quality (EQ) biosolids product as defined by United States Environmental Protection Agency (USEPA) Part 503 biosolids regulations. All biosolids generated at the WWTP were previously disposed in a landfill at a high cost ($97 per ton). Exeter Township adopted this technology to thermally dry their biosolids in an effort to reduce operational costs as well as to create opportunities to better use the residuals that result from wastewater treatment.

The Fenton Fenix CM 72/14 batch dryer (Photo 2) is capable of producing a granular biosolids product through a process of thermal drying, or heating the biosolids to at least 176°F. Exeter Township WWTP biosolids contain greater than 90 percent solids. Approximately 1,300 dry tons of Exeter granular product is generated annually.

The new EQ thermally dried biosolids product has potential in several markets as an alternative energy source, a soil conditioner, or plant nutrient supplement (fertilizer). Exeter Township was particularly interested in exploring the opportunity to have their product beneficially used as an alternative energy source for industries that could use dried biosolids as a fuel supplement.

Minimizing environmental impact from the use of biosolids is also of particular interest for Exeter Township. For instance, if biosolids were used as supplemental fuel for an industry such as a cement kiln operation, the residual ash would be used as part of the cement product, thus completely eliminating the need for any “waste” disposal, not to mention reducing the demand for non-renewable fossil fuels such as coal.

Given the variety of potential uses, Exeter Township contracted Material Matters to conduct a marketing study to identify market demand and market requirements of an EQ dried biosolids
product in the greater Berks County area. Material Matters worked closely with Exeter Township personnel to determine Township priorities in developing approaches for market development.

METHODOLOGY

Material Matters identified local industries that have the potential to use biosolids as a supplemental fuel source. Interview questions were prepared to gauge receptivity to the product and to gather data relative to preferred biosolids characteristics when used as a fuel source. Many interviews were conducted over the phone while others were conducted through email and in person. The purpose of the interviews and correspondence was to introduce the product, learn about market sector product specifications for energy markets, and discuss product specifications to meet individual end user needs.

A fact sheet was prepared describing the characteristics of Exeter Township’s dried biosolids for energy use. This informational brochure was used to introduce the product to potential end users. The fact sheet was developed to address potential user’s questions and describe the physical and chemical components of Exeter biosolids as compared to other common fuel sources.

Air emissions permitting and USEPA regulations were considered for industries that combust biosolids to ensure that use as a fuel is consistent with regulatory standards.

Based on findings from interviews, Material Matters offered suggestions to Exeter Township regarding product specifications to move the dried biosolids into higher value markets. Broad estimates of product value were based primarily on interviews and local market conditions.

CONCEPTUAL OVERVIEW OF FUEL PRODUCT

The Exeter Township dried biosolids product holds great potential for providing a renewable (continually produced) alternative energy fuel source to targeted industries. In the WWTP thermal drying process, biosolids are heated and dried (destroying pathogens and bacteria) to form very dry (90-99.9 percent solids) granules. They range in size from dust to approximately ¼ inch and they are lightweight and easy to handle. Exeter Township biosolids will generate 1.9 MMBtu/hour, or approximately 0.5 MW/hour (assuming 6,500 BTU/lb, 90.5% solids, and 1,300 tons annual production – per pilot study analytical results dated 9/17/08).

Thermally dried biosolids are being used to supplement traditional coal as a fuel source in the combustion process for the purposes of heat recovery and energy generation at Cemex plants in California and Kentucky (Garcia, pers. comm. 2010) and at a Lehigh Cement plant in Maryland (Stillwagon, pers. comm. 2010). Coal is a non-renewable resource, and therefore, supplementing traditional coal with dried biosolids will offset the use of non-renewable resources and provide fuel-intensive industries with a small fraction of “green” renewable biomass energy. However, energy intensive industries like cement and electricity generation require extremely high volumes of fuel to generate the heat necessary for the process to occur. For example, the Lehigh Cement plant in Evansville, Pennsylvania burns 20 tons of coal per hour, which is equivalent to 440 to 480 tons of coal per day (Bortz, pers. comm. 2010).
Although dried biosolids has roughly half the energy value of anthracite coal (6,500 BTU/lb at 90.5 percent total solids compared to 14,000 BTU/lb anthracite coal), it has a high volatile content, meaning that it burns readily. Due to a number of other factors, the net heat replacement is about 50 percent; or, the ratio replacement (biosolids for coal) is approximately 2:1 (Morton 2006, Garcia 2010, pers. comm.). Accordingly, twice the quantity of dried biosolids is required to generate an equal amount of energy produced using coal. For example, it would take at least 40 tons of Exeter Township biosolids to offset the coal usage at the Lehigh Cement Evansville facility for one hour, or nearly all of Exeter’s annual production (880 to 960 tons of biosolids) to offset the coal usage for one day.

Being an organic-based product, the biosolids contain carbon, which is the primary element in coal, a typical fuel burned to generate energy. The dried biosolids contain a mid-range energy value, comparable to low grade bituminous coal. Although dried biosolids have lower carbon content and higher oxygen, nitrogen, sulfur, moisture, and ash content, they have been successfully substituted for coal at rates up to 20 percent without significant air emissions impacts or cement quality issues (Garcia, pers. comm. 2010).

Several studies have shown that emissions of some elements/compounds decreased with the addition of dried biosolids as a fuel source (Morton 2006). A study on supplementing coal with dried biosolids at Lehigh Cement in Union Bridge, Maryland showed a slight decrease in carbon monoxide (CO), total hydrocarbons, and sulfur dioxide (SO2) emissions, but an increase in nitrogen oxide emissions (NOx, a greenhouse gas) (Morton 2006). However, this initial pilot study utilized biosolids mixed with pulverized coal fuel, which is believed to have increased the rate of combustion thereby increasing NOx emissions (USEPA 2006). Alternate feed locations were investigated in an effort to reduce the NOx emissions while maximizing the use of dried biosolids (USEPA 2006). Further studies have shown that NOx emissions can be reduced by injecting dewatered biosolids into the process at a point within a specific range in temperature (1600 to 1700°F), typically where the exhaust gases leave the kiln (USEPA 2006). This causes the ammonia present in the biosolids to react with oxygen, forming nitrogen and water thereby reducing NOx emissions. Additional stack testing at the Lehigh Cement facility has shown that burning dried biosolids in the kiln did not increase NOx emissions, as opposed to increased NOx emissions associated with burning in the calciner (Hsu, pers. comm. 2010).

Biosolids contain appreciable amounts of mercury, which is readily released into the air as a vapor when burned. Mercury content in fuel is of specific concern at this time since new United States Environmental Protection Agency (USEPA) regulations limiting mercury emissions will become effective in 2013 (Hsu, pers. comm. 2010). There is almost no control over mercury vapor; therefore regulators expect it to be in air emissions. One of Lehigh Cement’s air permit conditions is to significantly lower mercury emissions at the Union Bridge, Maryland facility (Hsu, pers. comm. 2010).

The ash content from Exeter biosolids (25 percent; per pilot analytical results dated 9/17/08) is appreciably greater than the ash content of coal (3 percent). At a 2:1 replacement ratio and significantly greater ash content, ash disposal may become a concern for energy generating facilities. Whereas energy generating facilities must dispose of ash produced through the
combustion process as a waste byproduct, cement and lime kilns use the ash as an ingredient in their products; a marked benefit of these industries.

The price for dried biosolids used as supplemental fuel fluctuates as supply, demand, disposal options, and the cost of coal varies. Nationwide, biosolids prices (for fuel) range from free to $50 per ton (e.g. it is most expensive in areas like Florida where coal is also very expensive) (Garcia, pers. comm., 2010). However, the price for dried biosolids as a fuel in the Berks County, Pennsylvania region is estimated at $0-15 per ton.

FEDERAL AND STATE PERMITTING

Recently, the USEPA has proposed revisions to several rules which will affect the combustion, or incineration of biosolids. First, biosolids will be considered a “solid waste” (in the combustion process) per the Resource Conservation and Recovery Act (RCRA). Secondly, USEPA proposed regulation revisions to area and major source facilities (boilers) and incineration units. Essentially, biosolids combusted in an incineration unit or a boiler will be subject to the more stringent Clean Air Act (CAA) Section 129 standards, which include new source performance standards (NSPS) and maximum achievable control technology (MACT), requiring monitoring of nine pollutant emissions (including NOx). These new regulations, may require incinerators and boilers burning solid waste (e.g. biosolids, whole tires) to meet certain standards that they otherwise may or may not have been previously required to attain. However, these emissions standards are not specific to biosolids; the facility should already have to meet certain regulations, such as Section 112 or Section 129 standards. The concern with USEPA’s proposed change in regulations is that facilities that are currently subject to the less stringent Section 112 standards will be held to the more stringent Section 129 standards if they begin combusting biosolids. Several permits are required before biosolids can be combusted as a supplemental fuel in Pennsylvania; these permits are summarized below.

Air Quality Permit

Facilities that combust biosolids in an incinerator for heat recovery or energy generation will be required to obtain an air quality permit from the Pennsylvania Department of Environmental Protection (PADEP) Bureau of Air Quality to ensure emissions meet certain regulations, as discussed above. Biosolids can be combusted along with other municipal waste, residual waste, or any other energy source (i.e. coal); however, the facility may be required to obtain additional permits to use biosolids as a fuel source. The air quality permit is the responsibility of the incinerating facility.

Beneficial Use General Permit

In order to beneficially use biosolids for the purposes of energy recovery, a General Permit (GP) is required from the PADEP Bureau of Waste Management. Currently, there is no GP in place which authorizes the burning of biosolids as a fuel; however, a new GP would need to be developed and approved prior to beneficial use as a fuel (Vu, pers. comm., 2010). This permit can be somewhat generic, including different types of incinerators (such as fluidized bed combustors, cement kilns, etc.), in order to keep the permit open-ended for a variety of future
energy uses. Acquiring this permit will be the responsibility of biosolids generator (Exeter Township).

POTENTIAL BIOSOLIDS USERS IN THE ENERGY MARKET

In terms of identifying potential biosolids users in the energy market, this study focused on industries that use fuels comparable to biosolids (coal and wood) and have infrastructure that can support the burning of biosolids (i.e. cement and energy facilities).

Exeter Township dried biosolids can be used as a recycled alternative energy source in the community (Figure 1). Based on Exeter Township’s marketing objectives, a number of large and small-scale fuel consumers were identified to market Exeter biosolids as a fuel source.

Industries supplementing traditional fuels with biosolids include energy generating facilities and cement kilns, many of which use coal as a primary fuel source. In addition to combusting dried biosolids for electricity generation or consumption at cement kilns and other large energy generating facilities, Material Matters evaluated small-scale facilities that may need a fuel source seasonally, such as greenhouses. Dried biosolids is a good fuel source, particularly for cement kilns; however, there are also a number of drawbacks to using biosolids as a fuel (Table 2).

Table 2. Benefits and challenges associated with biosolids use as fuel.

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biosolids are renewable / continually produced</td>
<td>High ash content (25%) compared to coal (3%)</td>
</tr>
<tr>
<td>Biosolids have a moderate BTU / energy value</td>
<td>2:1 replacement ratio (for equal energy generation when compared to coal)</td>
</tr>
<tr>
<td>Biosolids are available long term</td>
<td>Storage concerns (combustion)</td>
</tr>
<tr>
<td>The chemistry of biosolids ash is similar to coal (silica, alumina, and calcium) – key for cement industry</td>
<td>Low available supply of dried biosolids (small fraction of total energy requirement of facility)</td>
</tr>
<tr>
<td>Easy transport / handling</td>
<td>Emissions testing requirements</td>
</tr>
<tr>
<td>Relatively inexpensive fuel source</td>
<td>Fuel product monitoring requirements</td>
</tr>
<tr>
<td></td>
<td>Permitting – fuel user facility and WWTP</td>
</tr>
<tr>
<td></td>
<td>May generate odors (transit/storage/combustion)</td>
</tr>
<tr>
<td></td>
<td>Potential political / social concerns</td>
</tr>
</tbody>
</table>
Figure 1. Exeter Township Biosolids Renewable Energy Use in the Community
Due to the specifics involved in the combustion process, cement kilns, electrical generating facilities, and any other energy-intensive facility must make financial and operational investments in their plant to utilize biosolids as a fuel source. The investment includes coordinating with the appropriate agencies to obtain necessary permits and approvals to combust biosolids, developing control requirements, conducting stack testing, considering environmental fees, conducting additional maintenance, making physical plant upgrades (e.g. storage facility for biosolids), and considering operational changes at the plant to provide for receiving, storing, and utilizing the biosolids. This process can take several years and require substantial investment of capital. At this time, none of the facilities interviewed have the permits necessary to begin utilizing dried biosolids as a fuel source in their Pennsylvania facilities.

The fuel/energy market is further described in this section in terms of large consumers, including cement kilns, lime kilns, and energy generating facilities, as well as small consumers (seasonal heating). Supplemental information and specific details with regard to interviews for each facility evaluated in the energy market are included in the following sections.

Cement Kilns

Cement kilns are the largest pyro-processing facilities in the world and have many extreme operating characteristics; they require vast amounts of energy in the production of cement. A cement kiln that produces 6,000 tons of cement per day will consume 10,000 tons of raw materials and can burn over 750 tons of coal (Morton 2006). The raw materials used to manufacture cement include limestone (calcium), sand (silica), clay (alumina), and iron, all of which are inorganic (ash) components of dried biosolids. The physical characteristics of dried biosolids are similar to and chemically compatible with typical raw materials and can therefore be substituted in considerable amounts and still produce a good quality cement product.

As described by Morton (2006), the combustion process at cement kilns achieves the following characteristics that are important for the “removal” of dried biosolids from the environment:

1. The high oxygen/high temperature combustion zone ensures complete oxidation of organic components;
2. Long retention time combined with turbulent mixing of raw materials ensures complete chemical incorporation of inorganic components.

However, there are two characteristics of dried biosolids that can limit the amount of biosolids used in a cement kiln (Morton 2006).

1. The higher moisture content in the dried biosolids adds to the exhaust gas volume and absorbs heat, which could reduce production rates if the kiln is not equipped with sufficient fan capacity;
2. The phosphorus content in the dried biosolids ash ends up in the cement product, and if phosphorus concentration in the cement “clinker” approaches 0.6 percent, it can retard the concrete setting times.

A substitution of up to 20 to 25 percent biosolids may be used in the cement kiln without incurring any quality problems in the cement (Garcia, pers. comm., 2010). Quality problems are typically spurred by unsuitable chemical content characteristics of the ash (e.g. excessive
phosphate in the ash). However, phosphate will likely not cause a problem as the quantity of biosolids to be burned in the kiln is low. For instance, the Lehigh Cement Company Evansville Plant in Berks County anticipates burning up to 30-50,000 tons of biosolids annually upon approval of their air permit application.

**Lehigh Cement Company**

Cement kilns require vast amounts of fuel in the production of cement and could easily utilize all of Exeter Township’s annual biosolids production. Material Matters contacted Lehigh Cement Company to gauge their interest in supplementing their primary coal fuel source with dried biosolids. Exeter Township is in a unique situation as the Lehigh Cement Company’s Evansville Plant is located locally within Berks County, Pennsylvania and is already considering burning dried biosolids as a supplemental fuel source. The Evansville Plant is unique in that it has two kilns, *each* of which currently burn 10 tons coal/hour, or 220-240 tons coal/day, or 7,000 tons of coal/month (Bortz, pers. comm., 2010). Additionally, the Evansville Plant (utilizing both kilns – 14,000 tons of coal per month) produces approximately one million tons of cement per year. The Lehigh Cement Company’s Evansville Plant is anticipating burning two to five tons of biosolids per hour as a supplemental fuel (Stillwagon, pers. comm., 2010).

The Lehigh Cement Company’s Evansville Plant is already involved in the air quality regulatory process to get approval to use biosolids as a supplemental fuel source. Lehigh Cement submitted their air quality “plan approval application” concerning biosolids to PADEP on January 24, 2008 (Weaver, pers. comm., 2010). This has not yet been approved, because of various issues and the USEPA re-interpretation of the existing nonattainment new source review regulations (which would require significant regulatory hurdles to be overcome by Lehigh Cement). This has delayed the permit process and at this point, it is likely that Lehigh Cement will submit a new Plant Applicability Limit (PAL) application in lieu of the new source review application (Weaver, pers. comm., 2010). The PAL has not yet been received by PADEP; it would need to be reviewed and approved prior to PADEP continuing their review of the plan approval (Weaver, pers. comm., 2010). PADEP was not forthcoming with an estimated turnaround time for reviewing/approving either of these applications.

Lehigh Cement Company is familiar with utilizing “solid waste” products as fuel sources, as they currently burn whole tires at their Evansville plant and are subject to the more strict Clean Air Act Section 129 air quality standards. Lehigh Cement Company has not yet acquired a supply of biosolids for the Berks County facility, and their Purchasing & Material Manager has expressed interest in Exeter’s product, particularly since Exeter is located within Berks County (Stillwagon, pers. comm., 2010). Lehigh Cement Company feels that establishing a relationship with Exeter Township may aid them politically in acquiring the permit to utilize biosolids as a fuel source, particularly since they have experienced some resistance from local residents in Berks County (Stillwagon, pers. comm., 2010). Other communities have also sought to stop burning biosolids near their homes.

Lehigh Cement Company does not require a specific grain size; however, they will require a constant supply of biosolids throughout the year to ensure a balanced inorganic content in the ash for a good quality cement product. Therefore, the cement plant will require a contractual relationship with a biosolids supplier. The contract term length (e.g. 5-10 years) and the amount
of biosolids (e.g., ~100 tons per month) is negotiable based on the term/amount Exeter feels is feasible, as long as they supply it on a regular basis throughout the year.

Lehigh Cement Company plans to construct a biosolids silo at the Evansville Plant at some future date which will hold up to 800 tons of biosolids (Stillwagon, pers. comm., 2010). At a minimum, they anticipate burning two tons of biosolids per hour per kiln which means the supply in the storage silo will last several days. They do not plan to store biosolids for any significant length of time in the silo because they do not plan to install a costly dessicator system to reduce the moisture-induced heat buildup which can occur with long-term storage (Stillwagon, pers. comm., 2010).

The Evansville Plant will accept biosolids all year, unless the facility is shut down due to planned or unplanned outages. Planned outages typically occur for durations of four weeks or less while unplanned outages typically affect one kiln at a time for durations of less than one week (Stillwagon, pers. comm., 2010). Since the plant has two kilns (one kiln runs while the other is down), it is unlikely to decline biosolids for an extended time. Exeter Township’s on-site storage silo should be adequate to accommodate outages.

**Cost:** The price for dried biosolids as a fuel in cement production is estimated at **$0-5 per ton**.

Due to the significant financial and infrastructure investments by Lehigh Cement Company in order to utilize biosolids as a fuel at their Evansville Plant, they are not willing to pay for biosolids at this time, but may be willing to consider a small fee per ton (Stillwagon, pers. comm., 2010). They expect to receive biosolids at their facility at no cost (for product or transportation); however, they may be willing to consider mitigating the cost of transportation for Exeter Township, particularly since both are located in Berks County (Stillwagon, pers. comm., 2010). Transportation costs can vary depending on hauling weight and distance traveled.

A summary detailing the pros and cons of beneficially using Exeter’s biosolids at Lehigh Cement Company’s Evansville Plant are outlined in Table 3.

Table 3. Pros and cons of beneficially using Exeter’s biosolids at Lehigh Cement Company’s Cement Plant in Evansville, PA.

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ability to take product regularly throughout the year</td>
<td>• Low market value of $0 (potentially $5)</td>
</tr>
<tr>
<td>• Large quantity user, prefers bulk</td>
<td>• User is not yet permitted to use or store biosolids (approval is not guaranteed)</td>
</tr>
<tr>
<td>• Interest among consumer to use “green” energy</td>
<td>• User is waiting for PADEP permit approval before building biosolids storage silo</td>
</tr>
<tr>
<td>• Short term storage may be available</td>
<td>• Unexpected plant outages could limit biosolids export from WWTP to user at times</td>
</tr>
<tr>
<td>• Grain size not important</td>
<td>• Multi-year contract is required</td>
</tr>
<tr>
<td>• Zero waste disposal (ash used in cement)</td>
<td>• Valuable carbon and nutrient content burned in combustion process</td>
</tr>
<tr>
<td>• Offsets non-renewable fuel (coal) use</td>
<td>• Is not near-term option</td>
</tr>
<tr>
<td>• Sister facility in MD is already using biosolids</td>
<td></td>
</tr>
<tr>
<td>• Value in relationship with Lehigh Cement Co.</td>
<td></td>
</tr>
<tr>
<td>• Evansville Plant biosolids permit in progress</td>
<td></td>
</tr>
</tbody>
</table>
Evansville Plant currently subject to Section 129 emissions standards

**Lime Kilns**

Lime production is a very energy intensive process that primarily uses coal as a fuel, but the industry is beginning to seek other sources of biofuels to blend with coal. Pennsylvania has four locations where lime is quarried and processed into quicklime and hydrated lime: Annville, Hanover, York, and Bellefonte/Pleasant Gap. The production of lime products such as “quicklime” and “hydrated lime” consists of calcination and hydration of crushed limestone. Part of the extracted stone, selected according to its chemical composition and granulometry, is calcinated at about 1,000°C (1,832°F) in different types of kilns, fired by such fuels as natural gas, coal, fuel oil, lignite, and others (Wikipedia 2010). The CO₂ of the stone is released to produce calcined dolomitic lime or quicklime.

Similar to cement production, lime production requires large quantities of fuel and could easily utilize all of Exeter Township’s annual biosolids production. Material Matters interviewed Carmeuse Natural Chemicals (Carmeuse) to gauge their interest in supplementing their primary coal fuel source with Exeter Township’s dried biosolids. Carmeuse produces quicklime and hydrated lime at its Annville facility. They are a leading global producer of lime, high calcium limestone, and dolomitic stone produced from quarried limestone.

The Carmeuse Annville Plant is located in Lebanon County, Pennsylvania within 53 miles of Exeter Township. They are not currently using biosolids as a fuel, but are considering biosolids as a supplemental fuel source. Other biofuels they currently use include glycerol, plastics, and petroleum coke. The Annville Plant burns 250 tons coal/day, or 7,500 tons of coal/month (Reider, pers. comm., 2011) in a rotary kiln. The Annville Plant is considering combusting biosolids as a supplemental fuel and will likely accept biosolids up to a volume that will not compromise their air quality permits and operation (fouling) of their equipment. Because there is little experience with combusting biosolids in a rotary kiln for lime production, bench and full-scale emissions testing will need to be conducted.

| **Cost:** The price for dried biosolids as a fuel in lime production is estimated at **$15 per ton.** |

Due to the significant cost for coal and potential future incentives for reducing greenhouse gases, Carmeuse has indicated that they are willing to pay for biosolids (Reider, pers. comm., 2011). They indicated a willingness to pay for biosolids, FOB (as delivered to their facility); in fact, they would be willing to pay for biosolids based on the Btu value compared to coal (Reider, pers. comm., 2011). Transportation costs can vary depending on hauling weight and distance traveled. As it is currently understood, there is no additional infrastructure necessary to store and feed biosolids into this processing plant. Therefore, costs associated with bench and pilot testing and permitting would be the primary expenses for Carmeuse to consider. A summary detailing the pros and cons of beneficially using Exeter’s biosolids at the Carmeuse Annville Plant are outlined in Table 4.
Table 4. Pros and cons of beneficially using Exeter’s biosolids at Carmeuse lime production facility in Annville, PA.

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ability to take product regularly throughout the year</td>
<td>• Market value of $15 per ton uncertain (based on one discussion)</td>
</tr>
<tr>
<td>• Large quantity user, prefers bulk product</td>
<td>• User would have to apply for PADEP permit approval before using or storing biosolids</td>
</tr>
<tr>
<td>• Interest among consumers to use “green” energy</td>
<td>• PADEP approval is not guaranteed</td>
</tr>
<tr>
<td>• Short term storage will be available</td>
<td>• Unsure of timing for test burn and permitting</td>
</tr>
<tr>
<td>• Grain size not important</td>
<td>• Valuable carbon and nutrient content burned in combustion process</td>
</tr>
<tr>
<td>• Ash volume small (overall) and ends up in lime kiln dust</td>
<td></td>
</tr>
<tr>
<td>• Offsets non-renewable fuel (coal) use</td>
<td></td>
</tr>
<tr>
<td>• Already taking other by-products</td>
<td></td>
</tr>
<tr>
<td>• Willing to pursue test burns and air permitting</td>
<td></td>
</tr>
<tr>
<td>• Carmeuse currently subject to Section 129 emissions standards</td>
<td></td>
</tr>
<tr>
<td>• Moderate market value of $15 per ton</td>
<td></td>
</tr>
</tbody>
</table>

Energy Generating Facilities and Other Large Energy Consumers

Similar to cement and lime kilns, energy generating facilities and large energy consuming facilities require vast amounts of fuel to either generate energy or produce a product (i.e. paper). These facilities could utilize all of Exeter Township’s annual biosolids production, and would receive biosolids as a fuel all year long. Unlike Lehigh Cement Company, these facilities have not begun the ‘investment’ process – upgrading their infrastructure or applying for an air quality permit – which is required to utilize biosolids as a supplemental fuel source.

Material Matters contacted several energy generating facilities and facilities utilizing large amounts of coal or wood as fuel to gauge their interest in supplementing their traditional fuel source(s) with Exeter’s dried biosolids. Supplemental information about Exeter’s biosolids (fuel use fact sheet) and samples of the material were provided to these facilities for consideration.

- **Evergreen Community Power / United Corrstack** (Reading, Pennsylvania)
  - Wood/biomass facility
- **PA Bureau of Facilities and Management** (Reading and Harrisburg, Pennsylvania)
  - Coal burning facilities
- **Suez Energy Generation** (Northumberland, Pennsylvania)
  - Wood burning facility
- **Glatfelter Pulpwood Company** (Spring Grove, Pennsylvania)
  - Fuel oil and propane facility with coal-fired power plant on site

**Evergreen Community Power / United Corrstack**

Evergreen Community Power and United Corrstack (Evergreen Power), a member of Interstate Resources Paper Division, is located in Berks County. The facility has a circulating fluidized bed and wood/biomass boiler and steam generator which produces 25 MW of electricity. The facility
is continuous operation (24/7) and shuts down just twice per year for scheduled maintenance. The facility currently processes construction and demolition (C&D) waste and is interested in evaluating dried biosolids as a fuel.

Prior to utilizing biosolids as a fuel, Evergreen Power would have to apply for a permit from PADEP and analyze the biosolids for a number of parameters, including ash, total solids, and TCLP (Fares, pers. comm., 2010). They are currently paid $5-20 per ton to receive fuel in the energy value range of 4,300-7,000 BTU/lb, depending on how clean the product is (excessive trash, particles/dust will even be rejected) (Fares, pers. comm., 2010). Fuel materials can either be delivered to the facility, or they have trucks which can pick up materials. They test every load to ensure permit limits are not exceeded and they have a “good track record” with PADEP (Fares, pers. comm., 2010).

The company is currently concentrating on building a biomass processing facility (Creative Fuels, LLC) adjacent to the plant to provide fuels to the power plant.

**PA Bureau of Facilities and Management**
Several state office buildings and other facilities throughout Pennsylvania are provided with electricity and heat by on site coal boilers. Namely, there are two locations with small coal boilers which support office buildings: One in Berks County and the other in Dauphin County. The Energy Manager for Pennsylvania Bureau of Facilities and Management stated that either of these two locations or any other facilities which are not currently emission compliant may be worth evaluating for supplementing traditional coal fuel with dried biosolids (Stultz, pers. comm., 2010). Mr. Stultz further stated that it may be easier and more efficient for a facility struggling with air quality issues to utilize the biosolids (and minimize coal use) to meet air quality standards, particularly since some research has shown decreased emissions of certain pollutants when burning biosolids. Unfortunately, due to the Pennsylvania Coal Act, state buildings are required to use coal as a fuel source unless they can prove significant cost savings using the alternative fuel business model (Stultz, pers. comm., 2010).

**Suez Energy Generation**
Suez Energy Generation Company, located in Northumberland County, is a 100 percent wood (woody chips and sawdust) burning energy generating facility. Mr. Goshorn (pers. comm., 2010) stated the facility is open to alternative fuel sources, though they would have to undergo a lengthy process of testing the material, checking for moisture, emissions testing, building a biosolids storage facility, and obtaining the necessary permits. The facility currently consumes 600 tons of wood products per day, equivalent to 25 tractor trailer loads per day, and has been operating for the last 22 years (Goshorn, pers. comm., 2010). Additionally, fuel is typically delivered to their facility by the fuel source providers. Since the local township is pushing for green power, he is interested in exploring the possibility of supplementing fuel with dried biosolids.

**Glatfelter Pulpwood Company – Spring Grove Facility**
Glatfelter is a paper company with a facility located southwest of York, PA. Most of Glatfelter’s boilers at the Spring Grove facility use fuel oil and propane; however, they have a coal-fired power plant on site that uses “huge” amounts of coal (Strine, pers. comm., 2010). Sulfur
emissions compliance is critical for this facility and the dried biosolids would be considered as a supplemental fuel source as long as it did not add to pollutant emissions. Due to the higher sulfur content as well as the high moisture content in Exeter biosolids as compared to coal, Mr. Strine stated that they would have to fully evaluate the biosolids characteristics/emissions prior to considering this product as a supplemental fuel source (Strine, pers. comm., 2010).

Cost: The price for dried biosolids as a fuel in this region is estimated at $0 per ton.

Due to the significant financial and infrastructure investments which must be undertaken by the aforementioned facilities in order to utilize biosolids as a fuel, these facilities may not be willing to pay for biosolids at this time or they may even require financial investment assistance in facility infrastructure upgrades to accommodate the use of dried biosolids. Some facilities, such as Suez Energy Generation, expect fuels to be delivered to their facility, which means Exeter Township would bear the cost of transportation, as a minimum. Transportation costs can vary depending on hauling weight and distance traveled. A summary detailing the pros and cons of beneficially using Exeter’s biosolids at the above energy generating facilities are outlined in Table 5.

Table 5. Pros and cons of beneficially using Exeter’s biosolids at large-scale energy generating facilities.

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ability to take product throughout the year</td>
<td>• Low market value of $0</td>
</tr>
<tr>
<td>• Large quantity user, prefers bulk product</td>
<td>• Users have not begun lengthy permitting process to use or store biosolids</td>
</tr>
<tr>
<td>• Grain size not important</td>
<td>• Major investment required to utilize biosolids</td>
</tr>
<tr>
<td>• Interest among users to use “green” energy</td>
<td>• Ash must be disposed as waste</td>
</tr>
<tr>
<td>• Short term storage available (prior to use)</td>
<td>• Valuable carbon and nutrient content burned in combustion process</td>
</tr>
<tr>
<td>• Offsets non-renewable fuel (coal) use</td>
<td></td>
</tr>
</tbody>
</table>

*None of the facilities interviewed are currently permitted to burn biosolids, and none have begun the air permit application process or detailed emissions testing. This application and permit review process can take several years, and permit approval is not guaranteed. Major financial and infrastructure investment is required for potential end users to utilize dried biosolids as a fuel. Currently, coal burning facilities may be subject to less strict Section 112 emissions standards and it may be more difficult for them to comply with Section 129 emissions standards if they begin burning biosolids (when USEPA promulgates the regulations classifying biosolids as a solid waste during combustion). Potential end users may decide that too substantial an investment is required up front or future emissions compliance may be too cumbersome, and therefore may no longer be interested in considering biosolids as an alternative fuel source.

**Small Consumers – Seasonal Heating**

In addition to burning dried biosolids in the generation of energy or production of paper, lime, and cement, dried biosolids could also supplement coal or wood-fired boilers to produce heat in the wintertime. Exeter biosolids has a slightly higher energy value than wood (6,500 BTU/lb compared to 6,200 BTU/lb), making it a comparable supplement in terms of energy value.
Potential seasonal consumers include facilities requiring considerable heating during the winter, such as greenhouses.

Material Matters interviewed Glick’s Greenhouse, a large-scale retail nursery and greenhouse facility located in Oley, Pennsylvania, to gauge their interest in an alternative fuel source like Exeter dried biosolids. During our meeting, we learned that Glick’s Greenhouse had previously used dried biosolids several years ago to heat their greenhouses. A summary of their experience with the product follows (Glick, pers. comm., 2010).

The Glick’s burned four to five tons of another facility’s dried biosolids in their wood chip burner to heat their greenhouses. The biosolids produced a high quantity of ash when burned (typical for biosolids), and the ash was solid, “like metal/molten lava”, and difficult to remove from the burner. They had to clean out the burner often because the ash blocked air flow. Due to poor air flow in the burner, the biosolids produced a desirable slow, very hot burn. At first, they burned the biosolids alone, but the auger routinely jammed, so they later mixed it with the wood chips which worked much better. Mixing it also kept the wood chips burning longer; however, the ash was still difficult to remove from the burner. They anticipate that an “auto feed” system would work more effectively, but they were not equipped with that type of system and had to physically remove the ash (which was difficult). They projected that the process would be more efficient if the burner could automatically discharge the ash. They noted that the exhaust/smoke odor was unpleasant when burning the biosolids. It was stated that they smelled like the biosolids when handling or burning it.

Based on their previous experience burning dried biosolids several years ago to heat their greenhouses, they did not find the biosolids to be an acceptable fuel source for their facility (despite having it provided and delivered to them for free). Their primary reason was due to concerns about ash difficulties associated with their existing burner and the odor. They may be willing to reconsider if provided with a type of burner which could mitigate the ash issues, and if odor was alleviated.

| **Cost:** The price for dried biosolids as a fuel for a small consumer is estimated at $0 per ton. |

Due to the infrastructure investments required in order to effectively utilize biosolids as a fuel (upgrading the facility’s burner/boiler to automatically discharge the ash or burn at a different temperature), small-scale facilities are not be willing to pay for biosolids at this time and may not even use it if provided for free. A demonstration confirming odor mitigation may also be required. Additionally, Glick’s Greenhouse expects fuels to be delivered to their facility, which means Exeter Township would bear the cost of transportation. Transportation costs can vary depending on hauling weight and distance traveled. A summary detailing the pros and cons of beneficially using Exeter’s biosolids at small-scale seasonal heating facilities are outlined in Table 6.
Table 6. Pros and cons of beneficially using Exeter’s biosolids at a small-scale seasonal facility.

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Winter use</td>
<td>• Low market value of $0</td>
</tr>
<tr>
<td>• Short term storage available (prior to use)</td>
<td>• Seasonal use only</td>
</tr>
<tr>
<td>• Prefer bulk product</td>
<td>• Smaller quantity use</td>
</tr>
<tr>
<td>• Grain size not important</td>
<td>• Delivery expected by consumer</td>
</tr>
<tr>
<td></td>
<td>• Burner/boiler infrastructure investment may be necessary to effectively burn biosolids and handle ash</td>
</tr>
<tr>
<td></td>
<td>• Odor mitigation may be required</td>
</tr>
<tr>
<td></td>
<td>• Ash must be disposed as waste</td>
</tr>
<tr>
<td></td>
<td>• Valuable carbon and nutrient content burned in combustion process</td>
</tr>
</tbody>
</table>

*Other risks associated with this beneficial use option include an “unknown” factor with regard to changing regulations, as well as the functionality of burning biosolids in small quantities for seasonal heating. Depending on the final version of revised USEPA regulations, a greenhouse or any other facility burning biosolids as a fuel may be required to conduct emissions testing and obtain a permit to burn solid waste. This application and permit review process can take several years, and permit approval is not guaranteed. As described above, the interviewee was not interested in utilizing dried biosolids as supplemental fuel due to ash and odor issues, despite receiving product for free. Therefore, even if the facility was provided with a practical, efficient biosolids burner/boiler, the facility may decide that odor issues or even future regulated emissions compliance may become too cumbersome, and they may no longer be interested in utilizing biosolids as a supplemental fuel source.

PRODUCT SPECIFICATIONS

It is crucial that Exeter Township deliver a quality product to interested individuals at the specifications desired by the customer. Exeter Township should comply with the customer’s preference in order to establish a successful relationship. Product specifications were similar among the potential users and included the following:

- Biosolids must be at least 90% total solids, less moisture is better
- Grain size unimportant
- Must meet emissions standards
- Low mercury, sulfur content
- Moderate and consistent energy value
- Consistent delivery, year round
- Bulk delivery preferred by large consumers
- Pneumatic unloading required by Lehigh Cement
- “Green” fuel / alternative energy

ESTIMATED EXPENSES AND REVENUES

Based on 2009 Exeter Township biosolids production data, Material Matters estimated annual expenses and revenues associated with the energy beneficial use options (Table 7). Estimates are...
based on an annual production of 1,192 tons of dried biosolids product per year. These are compared to the current end use, which is landfill disposal.

Note that the transportation cost is the primary expense with all options. Developing methods to reduce transportation costs; such as using Township vehicles to haul small loads to smaller local users, would be useful. Focus should be on local end users when possible. Transportation to Lehigh Cement would require use of pneumatic trucks so reducing transportation costs for energy end use would be difficult.

Table 7. Estimate of expenses/revenues anticipated after implementation of different biosolids beneficial use programs.

<table>
<thead>
<tr>
<th>End Use Markets and Distances</th>
<th>Estimated Revenues (per ton)</th>
<th>Estimated Expenses (per ton)</th>
<th>Total Cost (per ton)</th>
<th>Total Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Trans</td>
<td>Tipping</td>
</tr>
<tr>
<td>Energy (Carmeuse Lime, 53 miles one-way)</td>
<td>$1</td>
<td>$15</td>
<td>$20</td>
<td>$0</td>
</tr>
<tr>
<td>Energy (Lehigh Cement, 23 miles one-way)</td>
<td>$0</td>
<td>$5</td>
<td>$18</td>
<td>$0</td>
</tr>
<tr>
<td>Landfill Disposal</td>
<td>$0</td>
<td>$0</td>
<td>$97</td>
<td>$ (97)</td>
</tr>
</tbody>
</table>

* This is a broad estimate only and includes approximated hauling/tipping fees. This does NOT include WWTP capital costs (dryer, fuel, etc.), operation and maintenance costs, or beneficial use marketing or permitting costs.

As part of the same biosolids marketing study, we conducted an exhaustive fertilizer study in addition to the energy study. Although not the focus of this paper, it is important to highlight some basic information regarding the fertilizer market in comparison with the energy market.

Seasonal use and quantity of end users is also an important consideration. Energy and agricultural use is estimated to be fairly constant throughout the year and can easily utilize Exeter’s entire annual production. Larger uses include energy, agricultural, turf, and soil blenders. Smaller uses include golf, athletic fields, and nurseries.

Estimated revenues and expenses in Table 7 do not include capital, operation and maintenance, marketing, and permitting costs; or costs for screening and/or bagging the dried biosolids. A graphic illustration of Table 7 is shown in Figure 2. In addition, permitting is necessary in order to beneficially use Exeter Township’s dried biosolids in the energy or fertilizer market.
Pennsylvania has developed the Alternative Energy Portfolio Standards (AEPS) program that assists in the management of alternative energy credits (AEC) and facilitates trades of AECs. The AEPS requires that an increasing percentage of electricity sold to retail customers in Pennsylvania is generated from alternative energy sources (PAAEPS 2011). The AEPS qualifies “biomass energy” as a Tier 1 alternative energy source. The weighted average price of a Tier 1 AEC was $4.77 in the 2010 energy year (price range $0.50 to $24.15) (PAAEPS 2011).

While many consider dried biosolids to be a form of renewable biomass, AEPS does not consider the combustion of biosolids to qualify as “biomass energy” in the AEPS program (Sherrick, pers. comm. 2011). Additionally, the bill (Act 213), does not allow provisions to add a new renewable energy source to the approved list. In order to modify the standard to include combustion of dried biosolids as a form of renewable biomass, an amendment to the legislation will be required (Sherrick, pers. comm. 2011).

Unfortunately, combustion of dried biosolids cannot count toward electrical generation from alternative energy sources at this time. Future changes in regulation or legislation related to renewable or alternative energy credits for burning renewable fuels may contribute to an increase in revenues and expenses for beneficial use in the energy and fertilizer markets.
increased level of interest in the use of biosolids as a fuel and in turn, develop demand for biosolids in the energy market.

**Maryland**

Maryland has a Renewable Portfolio Standard (RPS) which mandates 20 percent of energy must come from renewable sources by 2022 (MPSC 2011). The RPS allows facilities in Maryland to buy and sell renewable energy credits (RECs) on the open market. Currently, participation in this program is voluntary. A review of MDE’s website does not specifically include or exclude dried biosolids from the list of eligible renewable energy sources. Maryland Energy Administration stated that as long as dried biosolids is not explicitly excluded in the regulations, it will likely fall into the “qualified biomass” category as a Tier 1 renewable source (Rice, pers. comm. 2010). Accordingly, facilities combusting dried biosolids as a fuel supplement to generate electricity in Maryland can benefit from generating and selling RECs on the open market.

**Virginia**

Virginia Department of Mines Mineral and Energy (DMME) stated that Virginia currently does not offer any incentives, credits, or rebates specifically for the burning of renewable biomass. However, there is an ARRA-funded Biomass Energy Grant Program, a State Energy Program administered by DMME that provides financial incentives to businesses and governments to diversify Virginia’s energy supply sources. For the purposes of this program, dried biosolids are an eligible form of renewable biomass (DMME 2010).

In addition, Virginia Department of Environmental Quality has been tasked with developing regulations for renewable energy sources. The process to start developing the Renewable Energy Permit by Rule for biomass, waste to energy, and municipal solid waste began in early 2011, with final regulations due July 2012.

**DISCUSSION**

Understanding Exeter Township’s priority to focus on energy end use, or utilizing biosolids as a fuel supplement, we emphasized Lehigh Cement Company as a suitable potential end user. Lehigh Cement Company expressed interest in using Exeter dried biosolids as a supplemental fuel source after they receive approval from PADEP to combust biosolids at their Evansville, Pennsylvania plant. They stated that their Union Bridge, Maryland plant is permitted for, and is currently accepting dried biosolids as a supplemental fuel source from the City of Baltimore. Prior to beneficial use at their facilities, Lehigh Cement Company will need to obtain a sample of Exeter biosolids in order to run analytical tests on the product. Agreements will be required which will finalize details such as pricing, transportation, quantities, timing, and responsibilities.

However, Lehigh Cement Company does not yet have the necessary approvals and permits to combust biosolids at their Evansville plant. Additionally, prior to entering the energy/fuel market, Exeter Township WWTP will need to obtain a new general permit (GP) approving the beneficial use of biosolids as an alternative fuel from PADEP Bureau of Waste Management.
Currently, no such permit exists and a new GP will need to be developed – a process which can be time consuming.

In the meantime, Exeter Township has obtained PADEP’s general permit for land application of EQ biosolids (PAG-07) and plans to develop a program for use of biosolids as fertilizer or soil conditioner. Exeter Township is currently in the process of obtaining a Pennsylvania Department of Agriculture (PDA) fertilizer license, which will allow the Township to sell biosolids as an effective fertilizer. Exeter Township is currently exploring a variety of land application beneficial use outlets (i.e. agriculture, turf, golf course, athletic fields).

While Exeter Township works toward developing an agricultural beneficial use program, they are concurrently participating in a demonstration project with a local turf grower in Lancaster County, Pennsylvania. Demonstrations may be necessary to establish a value for many of the different beneficial use options outlined above. The study includes several dried biosolids treatments and one control (traditional fertilizer) treatment. The turf grower is particularly interested in dried biosolids since it is a granular form which would be relatively easy for use in the turf operation (similar to the fertilizers they already purchase and use). If the demonstration results are favorable, the turf grower indicated he would be willing to purchase dried biosolids for the turf farm as a replacement for their current blend of traditional fertilizers.

The superintendent of a local country club also expressed interest in conducting a demonstration of the product on an area of the golf course in the fairway currently not in play. If the results are favorable, the Township could consider dormant use or publish the data for other local golf courses to consider using the product. At this time, this demonstration project is in the preliminary planning stage.

When Lehigh Cement Company receives approvals and permits necessary to combust biosolids, a demonstration project should be initiated to ensure the product meets their specifications. The necessity for the establishment of well-controlled and well-designed product trials cannot be overstated. In order for Exeter Township biosolids to be accepted among consumers, it will be necessary for well-documented trials to show real, demonstrable results. If a product is given to or sold to end users without careful, deliberate experimental design, Exeter Township will be susceptible to incorrect or erroneous estimations of product effectiveness. If, for example, Exeter biosolids were provided to a consumer without a clearly documented trial plan, the consumer could attribute some negative outcome to the product, even if it is completely unrelated. To protect the integrity of the product, it is important that controlled, meaningful experiments be run with clear documentation of results. These results can then be used to demonstrate product effectiveness and value.

CONCLUSIONS

Biosolids contain moderate energy value (7,300 Btu/lb, dry weight basis) and similar organic-based characteristics to be an effective fuel supplement to coal in the energy market.

Use of biosolids as a fuel supplement in Pennsylvania is considered in future planning for Exeter Township’s beneficial use program; it is not a short-term end use option. At this time, no
facilities are permitted in Pennsylvania to combust biosolids as a supplemental fuel. Additionally, the PADEP Bureau of Waste Management does not offer a general permit for beneficial use of dried biosolids as a fuel source (to be obtained by the biosolids generator). Furthermore, Pennsylvania does not offer incentives to industry in the form of alternative energy credits for combusting dried biosolids, which is not currently considered to be a renewable energy source.

Accordingly, the energy market for dried biosolids is not yet developed in this region. The air quality permitting process is time consuming and industries may await the result of USEPA’s regulatory changes prior to entertaining supplemental fuel source considerations. Only one facility, Lehigh Cement Company, was identified to have begun the air quality permitting process associated with the use of a supplemental fuel source in Pennsylvania.

There is a limited volume of dried biosolids available in this region. Industries seeking to combust biosolids as a supplemental fuel require a large volume of dried biosolids to make the investment worthwhile.

The current market conditions are not driving high value and revenues for dried biosolids. This is a market worth exploring; however, consideration should occur after facilities have acquired permits and approvals. Exeter Township should limit expenses since little to no revenues are anticipated based on the energy value of the biosolids and the current conditions and expectations of the energy market. If Exeter Township will be required to cover the cost of transportation and also travel far distances to the combustion facilities, the energy end use may become cost prohibitive.

On the other hand, there is a robust land application market suitable for beneficial use programs in this region. Exeter Township plans to enter this market and land-apply biosolids as a fertilizer or soil conditioner under a self-managed program. Agricultural markets are currently generating revenues of $10 to $20 per ton. Exeter Township will delay entering the energy market with their supplemental fuel source until the market is better developed.

REFERENCES


Hsu, J. 2010. Air Quality Permits Program, Maryland Department of Environment. Personal communication regarding air quality permits to burn dried biosolids at the Lehigh Cement facility in Union Bridge, MD. Telephone: October 18, 2010.


