New York State Energy Research and Development Authority

Proof-of-Concept for Co-Digestion of Food Waste, Fats, Oil and Grease, and Wastewater Sludge Cake to Create Renewable Energy

Pilot-scale Demonstration of Spectrum BioEnergy's BioBeetle Biogas System at Albany County Sewer District's South Wastewater Treatment Plant

Final Report

August 2012

No. 12-22

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Prepared for the

**New York State
Energy Research and
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ACKNOWLEDGMENTS

We would like to express our utmost gratitude to our sponsors, the New York State Energy & Research Development Authority and the Albany County Sewer District, for their unwavering support and tireless assistance as we pursued this project. In addition, we would like to acknowledge our partners: Baker Commodities, Bimbo Bakery, the City of Watervliet, and Price Chopper Supermarkets, and thank them for their help and generosity.

ABSTRACT

Keywords: anaerobic digestion, BioBeetle System, biogas, biosolids, renewable energy, sludge cake, waste management, wastewater treatment

Anaerobic digestion (AD) is a series of processes in which microorganisms break down organic wastes from municipal, industrial, agricultural, and/or other applications in the absence of oxygen. The resulting products are biogas, which can be used as a renewable source of energy, and a nutrient-rich digestate that may be used as a fertilizer.

In this project, Spectrum BioEnergy (SBE) evaluated the potential of using anaerobic digestion as part of a low-cost, integrated waste management solution for municipal and other waste streams. A variety of organic wastes were co-digested in SBE's BioBeetle Biogas System, including sludge cake from the municipal wastewater treatment facility, as well as produce, household food waste, bakery, and fats, oils, and grease (FOG). The demonstration occurred at Albany County Sewer District's South Wastewater Treatment Plant.

The system was operated for more than ten weeks, during which time the feedstock composition was altered on a weekly basis. Biogas yields were up to five times greater when high-energy waste streams (bakery waste and FOG) were co-digested with sludge cake, as compared to digesting sludge cake as the sole feedstock.

A preliminary analysis of the cost savings associated with integrated AD was performed. Additionally, SBE outlined the steps required to achieve categorization of the digestate as Class A Biosolids, which would allow for unrestricted use as a home, lawn, and/or garden fertilizer. Upon conclusion of the demonstration it was determined that anaerobic digestion has the potential to be integrated in to a municipality's conventional waste management process, while providing environmental and other benefits that reduce the overall costs of the waste management process.

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Figures (Tables, Charts and Graphs)

SUMMARY

Spectrum BioEnergy operated its BioBeetle Biogas System at the Albany County Sewer District's South Wastewater Treatment Plant to demonstrate the anaerobic digestion capabilities of the system. In addition to sludge cake from the wastewater treatment facility, the demonstration included co-digestion of food wastes and fats, oils and grease (FOG), which were obtained from the City of Watervliet, Bimbo Bakeries USA, Baker Commodities, and Price Chopper.

Beginning in January 2012, approximately 500 pounds of organic waste were fed daily to the BioBeetle System. The system was deemed operationally-stable after eight weeks, once biogas yield was relatively constant and the percent reduction in volatile solids was consistently greater than 40%. Following stabilization, a new feedstock (residential food waste, bakery waste, produce, and/or FOG) was introduced to the digester on a weekly basis and the corresponding biogas production measured. The daily average biogas yield was calculated for each feedstock by averaging the production of seven days' worth of operation. Data presented in this report represent system performance during the ten weeks of operation after stability was achieved.

The greatest biogas yields were produced when sludge cake from the wastewater treatment facility was co-digested with high-energy waste (i.e., residential food waste, bakery waste, FOG). The mixture producing the highest yield had a 5:4:1 ratio of sludge cake, bakery waste, FOG, respectively, and produced in the range of 3,000 to 3,760 cubic feet (ft^3) of biogas per day (600 to 744 MMBtu), which is equivalent to approximately 70,790 kilowatt hours per year (kWh/year)[1]. Sludge cake alone produced 815 ft^3 of biogas per day (161.5 MMBtu), which is equivalent to approximately 16,618 kWh/year.

[1] Electricity was calculated using a 35% generator efficiency

BACKGROUND

Anaerobic digestion (AD) is a series of processes in which microorganisms break down organic wastes from municipal, industrial, agricultural, and/or other applications in the absence of oxygen. The resulting products are biogas and a nutrient-rich digestate. Biogas is a clean, renewable energy source that can be used in place of fossil fuel-derived natural gas for building heat or producing hot water, or can be converted to electricity or transportation fuel. AD is a proven technology with widespread economic and environmental benefits.

Wastewater treatment plants (WWTPs) in New York State account for approximately 3% of the state's total energy consumption. Wastewater sludge cake – a nutrient-rich organic byproduct of the wastewater treatment process – represent a potentially costly waste management challenge, but also a potentially significant source of renewable energy. It has been estimated that the potential energy embedded in industrial and municipal wastewater can be approximately two times the energy required for its treatment.[2] In addition to energy, significant quantities of nutrientscan be recovered.[3]

In New York State, there are 584 publicly owned treatment works that generate 1,000 dry tons of sludge cake per day. Of the 584 facilities, 293 (50%) convey the sludge cake to landfills, 147 (25%) beneficially use the sludge cake (e.g., digest anaerobically to produce biogas, compost to produce a Class A or B Biosolid, which can be land applied), 80 (14%) incinerate the sludge cake, and 64 (11%) dispose of the sludge cake using other methods.[4] Additionally, state regulators and municipal leaders have begun a dialog on the topic of encouraging food waste diversion from landfills. If food and other high strength wastes are diverted from landfills to AD systems located at WWTPs, the waste burden on the landfills could be reduced, with the subsequent potential of substantially increasing the amount of energy produced on-site at the WWTPs.

The project was managed by Spectrum BioEnergy (SBE), a biogas project developer and investor. SBE has a large-scale biogas plant operating in India that is converting 100 dry tons of sugarcane waste per day into BioCNG and organic liquid fertilizer. SBE has also developed the BioBeetle Biogas System, which was demonstrated in this project; an innovative, containerized, modular system for use in smaller-scale applications – one-half (½) to six (6) dry tons per day.

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[2] Water & Wastewater: Profiting from the Next Big Wave, Equilibrium Capital Group, Nov 2010

[3] ibid

[4] Biosolids Management in New York State, February 2005, NYS Department of Environmental Conservation, Division of Solid and Hazardous Materials

This project also included multiple partners, as follows:

- **The Albany County Sewer District (ACSD):** The ASCD has provided wastewater services since 1974. In 2011, the District treated an average of 51.5 million gallons of wastewater per day. All sludge cake generated by the ASCD are incinerated the at County's South and North wastewater treatment plants. Additionally, the District collects sludge cake from several smaller communities, which is also incinerated at the North plant.

- **The City of Watervliet**: Under the direction of Mayor Mike Manning, the City is a leader in promoting green initiatives. In 2012, the City initiated the Watervliet Organic Waste ("WOW") program, with the goal of diverting residential organic waste from landfills.

- **Bimbo Bakeries USA**: Bimbo Bakeries USAs originated in 1994 when, Grupo Bimbo, its parent company, purchased La Hacienda, a California tortilla company. Today, Bimbo Bakeries USA operates 33 bakeries and employs more than 15,000 associates; it is the nation's largest baking company.

- **Price Chopper**: Price Chopper dates back to 1900. Today, the chain's 128-store footprint extends beyond New York and Massachusetts, into Vermont, Connecticut, Pennsylvania, and New Hampshire.

- **Baker Commodities Inc.**: Baker Commodities is one of the nation's leading providers of rendering and grease removal services. Baker Commodities has more than 21 facilities across the United States that convert animal by-products into commercial commodities such as high-protein ingredients for poultry feed and pet food, and tallow, a valuable ingredient in soaps, paints, cosmetics, and more.

TECHNICAL EVALUATION

Quantifying Biogas Yield

Wastewater sludge cake is a lower-energy feedstock than many of the high strength feedstocks from industrial, agricultural, and/or other applications, such as dairy processing wastes, off-spec beverage wastes, and fats, oils and grease (FOG). The biogas yield of the sludge cake collected from the Albany County Sewer District was approximately 46 cubic meters (m^3) per dry ton of sludge digested. The key to improving the economics of many digester projects, is to increase the volume of biogas produced by the digester. This can be done by co-digesting high strength feedstocks with the sludge. A number of feedstocks were evaluated during this project, as was the associated biogas yield of each combination. All feedstocks were sourced locally. A list of these is provided in Table 1.

Table 1: Summary of Waste Types

Waste Type	Description	Source
Bakery	Cookies, Muffins	BIMBO Bakery
FOG	Fats, Oils, and Grease	Bakers Commodities
Household	Residential food waste	City of Watervliet
Produce	Fruits and Vegetables	Price Chopper Supermarket
Sludge	Sludge Cake	Albany County South WWTP

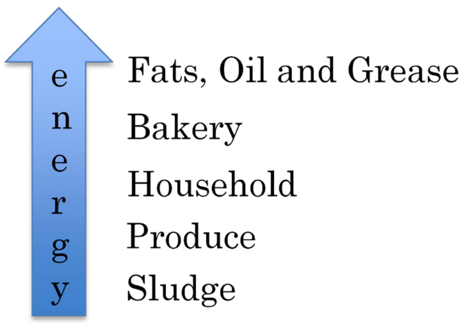
Table 2 provides information on the composition of the digester feedstock on a weekly basis.

Table 2: Percent Composition of Feedstock

Week	Sludge	Produce	Household	Bakery	FOG
1	100%	-	-	-	-
2	75%	-	12.5%	12.5%	-
3	75%	-	-	25%	-
4	75%	-	25%	-	-
5	75%	25%	-	-	-
6	70%	30%	-	-	-
7	50%	30%	20%	-	-
8	50%	-	-	50%	-
9	50%	-	-	45%	5%
10	50%	-	-	40%	10%

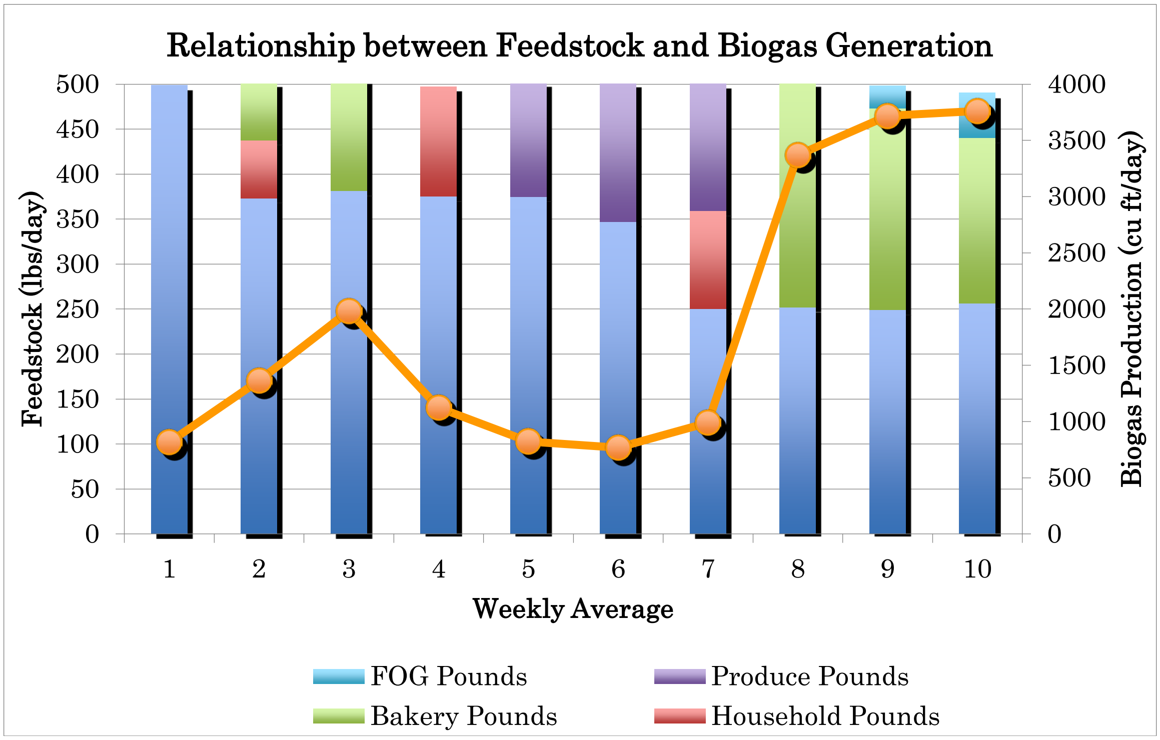
Figure 1 shows an energy hierarchy for organic waste streams. As will be observed in the following text, the data produced during the tenure of this work coincide with established research; fats, oil, and grease (FOG) yielded the greatest volume of biogas, followed by bakery wastes, residential wastes, off-spec produce, and sludge.

Figure 1: Energy Hierarchy for Tested Organic Waste Streams



As shown in Figure 2, biogas yields increased markedly with the addition of bakery waste and FOG to the digester. The digestion of equal amounts of bakery waste and sludge increased biogas yields by 300-400% compared to that generated when sludge alone was fed to the digester. In addition, a small addition of FOG (a 5:4:1 ratio of sludge to bakery waste to FOG) increased yields by another 20-30%. Addition of household waste also led to an increase in biogas generation; a mixture of 25% household waste/75% sludge resulted in increased biogas yields of approximately 35-41%. Surprisingly, however, produce and sludge demonstrated near equivalent energy yields.

Figure 2: Relationship between Feedstock and Biogas Generation (ft³)



Data was extrapolated from information generated by the ½ ton pilot unit to determine approximate daily yields that could be expected from a full-scale, one-ton unit. These are as follows:

- On a per ton basis, digestion of 100% sludge would yield 40-46 m^3 biogas
- On a per ton basis, a mixture of 75% sludge and 25% household waste would yield 55-64 m^3 biogas
- On a per ton basis, a mixture of 50% sludge and 50% bakery waste would yield 140-166 m^3 biogas
- On a per ton basis, a mixture of 50% sludge, 40% bakery waste, and 10% FOG would yield 170-213 m^3 biogas

For a complete 10-week comparative list of varied feedstock compositions and subsequent biogas question, please refer to Appendix A: Feedstock Composition and Biogas Generation.

Quantifying Energy Benefits

The energy benefits of anaerobic digestion are derived from the production of biogas and include:

1) direct use as a natural gas replacement
2) conversion into electricity via a prime mover
3) conversion into electricity with subsequent use of the thermal energy generated by the prime mover (i.e., combined heat & power (CHP) unit) for heat

4) upgrade to pipeline quality gas and inject into existing natural gas pipelines
5) compress into renewable transportation fuel.

Onsite use of the biogas-derived energy would enable a WWTP to reduce, or even eliminate, the need to purchase electricity and fuel from off-site sources, potentially representing a significant reduction in the cost of operations of the WWTP.

Figures 3 and 4 depict projected annual electricity and gas revenues from a ½ ton per day BioBeetle unit. The projected revenues assume a natural gas cost of $7.00/MMBtu[5], an electricity cost of $0.11/kWh[6], 35% generator efficiency, and use of 10% of the generated biogas to maintain a system temperature of approximately 35°C. Costs associated with capital expenditures, financing, operations and maintenance, and digestate management are not reflected in the projected revenues. On the other hand, the potential revenues from tipping fees and Class A or B Biosolids sales are also not reflected in the figures. The waste streams identified on the x-axis of the figures are defined as follows:

- Sludge = 100% sludge
- Sludge + Household (HH) = a mixture of 75% sludge and 25% household waste
- Sludge + Bakery = a mixture of 50% sludge and 50% bakery waste
- Sludge + Bakery + FOG = a mixture of 50% sludge, 40% bakery waste, and 10% FOG

[5] Negotiated gas rate for Albany County Sewer District for October 2012 – October 2014
[6] Estimated electricity rate for Albany County Sewer District

Figure 3: Projected Annual Savings from Electricity Production

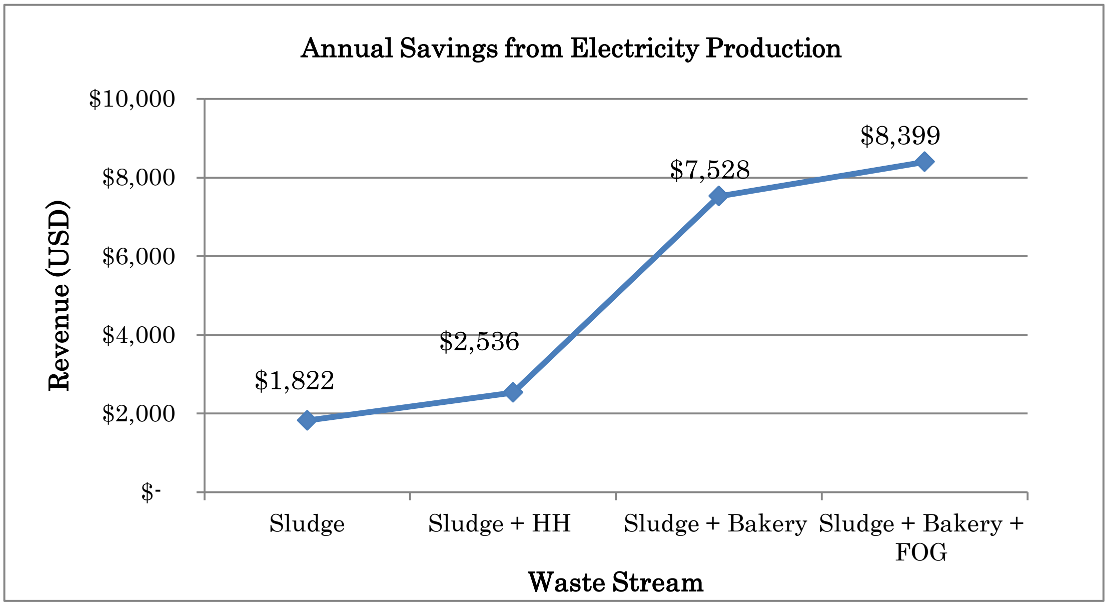
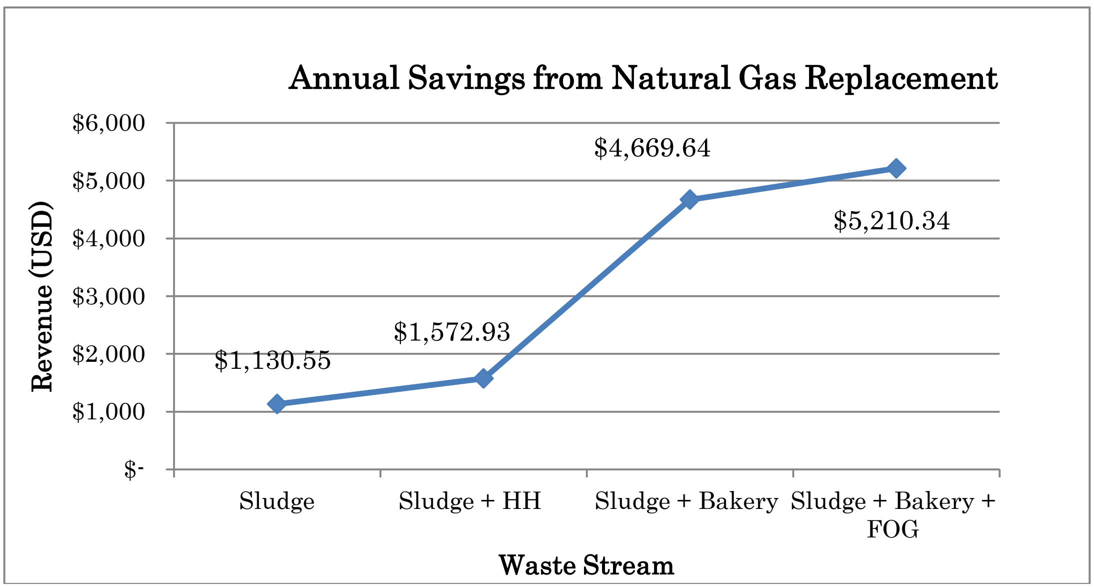


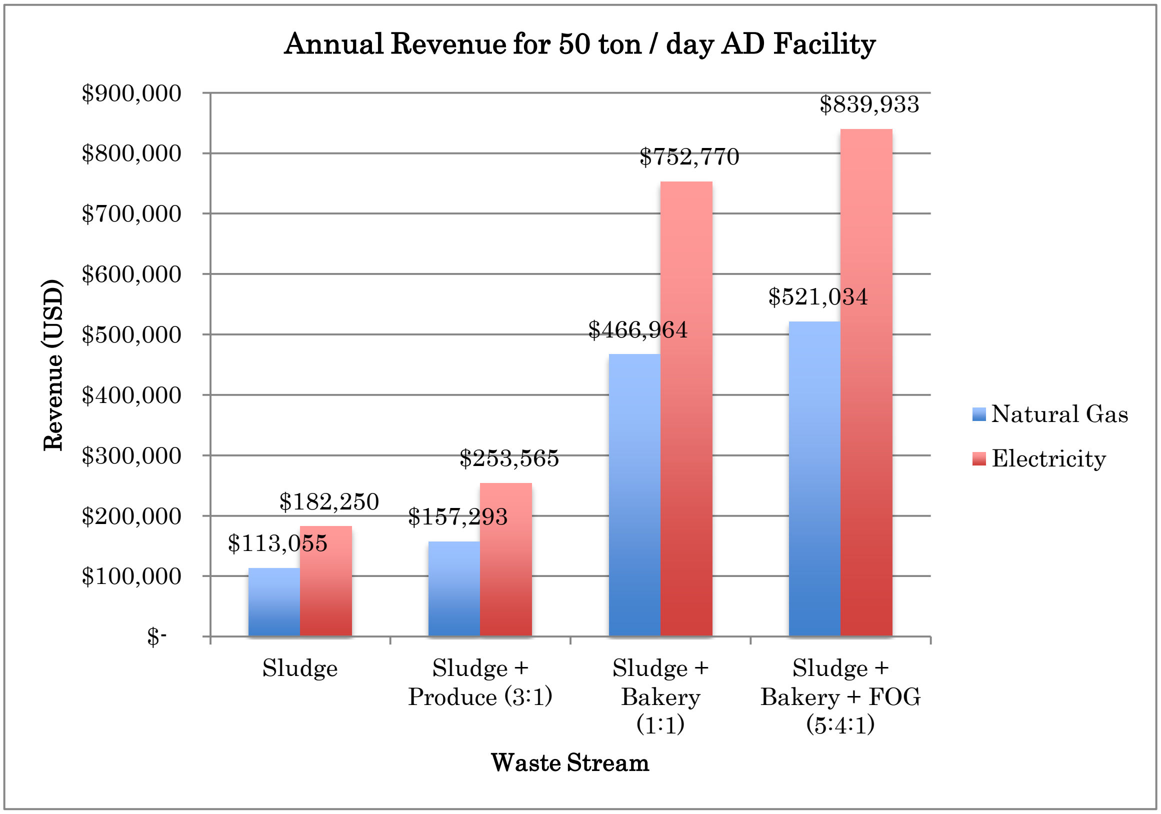
Figure 4: Projected Annual Savings from Natural Gas Replacement



For a complete list of the projected annual impact of a BioBeetle System associated with each of the various waste streams tested in this project, please refer to Appendix C.

While revenue projections shown in Figures 3 and 4 are based on a ½ ton pilot unit, at full-scale the potential revenues vary from thousands to millions of dollars per year, depending on the availability, volume, and types of supplemental feedstocks, as well as local energy prices. Figure 5 depicts projected revenues from a 50 dry ton per day BioBeetle system located at the Albany County Sewer District's South Plant.

Figure 5: Annual Revenue for 50 dry ton / day AD Facility



Observations based on Figure 8 include the following:

1. Revenue derived from electricity exceeds that derived from gas, which is largely due to the current low natural gas prices.
2. Revenue increases with digestion of higher-energy feedstocks.

Anaerobic digestion also offers a host of environmental benefits, including reduced greenhouse gas emissions, reduced pathogen levels, and dramatic odor reduction[7]. AD systems are associated with reduced emissions of greenhouse gases when the biogas generated by these systems replaces an equivalent amount of fossil fuel-derived energy.

[7] American Biogas Council website: www.americanbiogascouncil.org/biogas_biogasBenefits.asp

Biogas Analyses

The average composition of the biogas produced by the BioBeetle unit during the project was consistent with values from published literature, as follows:

- CH_4: 59.7 +/- 0.52
- CO_2: 37.9 +/- 0.40
- N_2: 1.9 +/- 0.38

Hydrogen sulfide (H_2S) analysis was also performed on the biogas. The concentration was 110,000 ppbv, which was higher than expected, due to a non-working hydrogen sulfide removal system. This could easily be remedied through replacement of the iron sponges in the system.

In a large-scale application the raw biogas would likely be treated (depending on the intended end-use) via one-or-more of the following processes:

1) H_2S removal
2) Moisture removal
3) Siloxane removal
4) Removal of CO_2 , N_2 and O_2

Post-AD Biosolids Analyses

During the course of the demonstration project, 40-60% of the post-AD biosolids (also referred to as digestate) generated by the BioBeetle System were recirculated to the head of the WWTP; a daily average of approximately 112 gallons. (*Please refer to Appendix C for more information.)* For a larger-scale project, the post-AD biosolids would have to be disposed of in an alternate manner. In order to land apply or compost the biosolids, rather than send them to a landfill, compliance with EPA standards would be required. Therefore, post-AD biosolids samples from the BioBeetle System were tested for heavy metals and pathogen concentration. Samples were also sent for NPK analysis.

The results of the heavy metals analyses are presented in Table 3. All toxic metals were found to be well below EPA's Table III limit, which is their most stringent standard for a biosolid given a "Class A" designation. A Class A Biosolid can be used in an unrestricted manner on lawns and in home gardens. [Note: the tested samples were derived from co-digested sludge and bakery waste (at a 1 to 1 ratio).]

Table 3: Toxic Metal Analysis

Metal	BioBeetle Digestate	EPA Table III Limit
Arsenic	BDL	41
Cadmium	BDL	39
Chromium	16.6	N/A
Copper	291	1500
Lead	45.8	300
Mercury	1.99	17
Molybdenum	BDL	N/A
Nickel	BDL	420
Selenium	15.2	100
Zinc	542	2800

In order to meet EPA's Class B Biosolids standards, for use in agricultural applications, the sludge cake must be anaerobically digested for at least 15 days at 35-55 °C. This is consistent with the manner in which the BioBeetle System is normally operated.

The sample sent for pathogen testing was derived solely from digested sludge, which should represent the feedstock with the maximum pathogen concentration compared to other feedstocks. The coliform colony count of the sample was 638 MPN/g, which is below the EPA limit of 1000 MPN/g required for the Class A Biosolids designation.

These data suggest that post-AD biosolids generated from the BioBeetle System meet the Class A Biosolids standards. Nevertheless, , to officially achieve the "Class A" designation, seven discrete samples must be analyzed for pathogenicity. Additionally, the EPA stipulates that the digestate must be further processed to reduce pathogens using one of five approved methods. *Please refer to Appendix E for a summary of processes to significantly reduce pathogens (PSRP) for biosolids amendment and sale.*

Therefore, for a full-scale, it would be necessary to further identify the steps and costs associated with treating the post-AD biosolids to meet Class A Biosolids standards. It would also be necessary to perform vector attraction reduction (VAR). It would then be possible to determine if achieving Class A Biosolids standards is feasible and perhaps even profitable.

The results of the NPK analysis are provided in Table 4. The digestate is nutrient-rich, particularly in nitrogen, in the forms of ammonia and ammonium salts. While ammonium ions are beneficial for plant growth and relatively harmless to aquatic life, high ammonia concentrations may present a potential environmental hazard. The pH of the digestate was 8.2, which is associated with an ammonia: ammonium ion ratio of approximately 1:9. Slight acidification of the post-AD biosolids, such that a neutral pH is achieved, should be explored; as the relative ratio of ammonia to ammonium ions would greatly decreased, as would the potentially harmful effects of ammonia to soil and groundwater systems.

Table 4: NPK analysis

Nutrient	BioBeetle Digestate (µg/g dry)
Ammonia	74300
Nitrate	520
Nitrite	96.3
Phosphorous	21000
Potassium	3770

PUBLIC EDUCATION

The BioBeetle demonstration project also served as an educational opportunity for a variety of government, academic and for-profit entities. Visitors included representatives from the following:

- New York State Department of Environmental Conservation
- New York State Empire State Development Corporation
- Michigan State University
- Cornell University
- Member of the Albany County Legislature
- Members of the Albany County Organics Committee
- Members of the Albany Common Council
- Local waste management companies

Members of the NYS Department of Environmental Conservation and SBE Team

CONCLUSIONS

The project successfully demonstrated the potential of using anaerobic digestion as part of a low-cost, integrated waste management solution for municipal and other waste streams. The key conclusions from the project are as follows:

1. It is technically feasible to co-digest a variety of organic wastes in the BioBeetle System along with sludge cake from a municipal wastewater treatment facility. These included produce-, household-, and bakery-waste, as well as fats, oils, and grease (FOG).
2. The co-digestion of food wastes and FOG with sludge cake resulted in up to a 5 time increase in biogas yield. The waste streams with the highest energy potential were FOG and bakery waste, followed by household waste, and, lastly, produce and sludge cake.
3. The co-digestion of food wastes and FOG with sludge cake resulted in up to a 5 time increase in revenues generated by the system.

SBE's ultimate goal is to develop a commercial-scale biogas plant at a wastewater treatment plant that is capable of co-digest sludge cake and regionally-derived organic waste. To this end, SBE plans to perform an analysis to gauge the technical, logistic, and economic feasibility of developing such a project at the Albany County Sewer District's South WWTP.

Appendix A: Feedstock Composition and Biogas Generation

The following table presents the weekly feedstock compositions and subsequent daily biogas outputs, as well as the percent solids of the incoming feed and outgoing effluent.

Wk	2012	Type of Waste (lbs/day)					Daily Biogas Output		Percent solids	
No.	Load Date	Sludge	HH	Bakery	Prod-uce	FOG	m^3	ft^3	Feed %	Effluent %
1	2/27–3/2	498	0	0	0	0	23.07	815	6.3	3.9
2	3/5–3/9	373	62	66	0	0	38.65	1365	7.3	4.7
3	3/12–3/16	381	0	124	0	0	56.15	1982	8.4	4.6
4	3/19-3/23	375	123	0	0	0	31.83	1124	8.1	4.9
5	3/26-3/30	375	0	0	127	0	23.28	822	7.9	4.8
6	4/2-4/6	347	0	0	155	0	21.72	767	7.2	4.8
7	4/9-4/13	250	109	0	141	0	28.06	991	8.9	4.8
8	4/16-4/22	252	0	250	0	0	83.17	2937	--	4.8
9	4/23-4/29	249	0	224	0	25	105.25	3717	15.6	5.2
10	4/30-5/06	256	0	184	0	50	106.46	3760	16.5	5.9

Key
Sludge = Wastewater Sludge Cake
HH = Household waste from City of Watervliet
Bakery = Bakery waste from BIMBO Bakery
Produce = Produce waste from Price Chopper
FOG = Fats, Oil and Grease from Bakers Commodity

Appendix B: Projected Annual Impact of BioBeetle System

Waste Type	Biogas generation (m^3/yr)	Natural Gas (MMBtu/year)	Homes heated	Electricity (kWh/yr)	Homes powered
Sludge	8,420	161.51	1.65	16,618	1.48
Sludge + Food/Bakery	14,110	273.86	2.79	28,094	2.50
Sludge + Bakery	20,495	393.23	4.01	40,340	3.59
Sludge + Household	11,620	224.70	2.28	22,928	2.04
Sludge + Produce	8,500	161.51	1.67	16,770	1.49
Sludge + Produce	7,930	154.48	1.56	15,646	1.39
Sludge + Produce + Household	10,240	196.62	2.01	20,213	1.80
Sludge + Bakery	30,360	667.09	5.96	59,912	5.33
Sludge + Bakery + FOG	38,420	737.31	7.60	69,985	6.80
Sludge + Bakery + FOG	38,860	744.33	7.67	70,790	6.86

Appendix C: Level of Digestate (aka Decant) Recycled and Disposed

Week of	Gallons Fed*	Gallons Disposed**	Decant Recycled	% Decant Recycled	% Decant Removed
2/27/12	264	125	139	53%	47%
3/5/12	249	109	140	56%	44%
3/12/12	220	102	118	54%	46%
3/19/12	225	76	149	66%	34%
3/26/12	239	106	133	56%	44%
4/02/12	246	114	132	54%	46%
4/09/12	208	144	64	31%	69%
4/16/12	219	215	4	2%	98%
4/23/12	225	131	94	42%	58%
4/30/12	206	59	147	71%	29%
		Average Percentage		48%	52%
	Average Percentage without Outlier			54%	46%

*Combined feed includes digestate/decant, water and sludge cake
**Digested sludge volume (decant only)
***Outlier is week of 4/16

Appendix D: Processes to significantly reduce pathogens (PSRP) for Biosolids Amendment and Sale

Class B Standards

In order to meet Class B Standards, pathogen testing requires:

- *7 samples – Geometric Mean <2,000,000 MPN/g or CFU (based on seven samples per event)*
  OR
- *1 of 5 approved PSRP methods*
  - Aerobic Digestion: 40 days @ 20°C no less than 60 days @ 15°C
  - Air Drying: 3 months with 2 months above 0°C
  - **Anaerobic Digestion: 15 days @ 35-55°C no less than 60 days at 20°C**
  - Composting: 40°C for 5 days with min 4 hours at 55°C
  - Lime stabilization: Add lime to raise pH to 12 after 2 hours of contact
  - Other as approved by permitting authority

Thus, AD of sludge cake successfully meets the requirements to achieve Class B Biosolids.

Class A Standards

In order to meet Class A standards, the effluent post AD-biosolids must be treated in a variety of ways.

To meet pathogen-level standards, along with a Fecal count of < 1000 MPN/g or Salmonella s.p. < 3 MPN/4g (which has been met in 1 individual sample from the project), one of 5 approved methods further reduce pathogens:

1. Time/temp depending on solids content
2. pH/time then drying to at least 50% solids
3. Testing for enteric viruses/viable helminth ova
4. Testing for reduction of these analytes
5. PFRP: composting, heat drying, heat treatment, TAD, beta ray irradiation, gamma ray irradiation, pasteurization, other methods as approved by the permitting authority

Vector Attraction Reduction (VAR) requirements

1. 38% VSR
2. Anaerobic – bench scale test (40 days)
3. Aerobic – bench scale test (30 days)
4. Aerobic – SOUR =< 1.5mg O2/hr @ 20°C
5. Aerobic – 14+ days @ >40°C (average > 45°C)
6. pH – 12+ for 2 hours then 11.5+ for 22 hours
7. Dry to 75% when stabilized solids used (digestate)
8. Dry to 90% when unstabilized solids used (undigested)
9. Sub injection (no significance after 1 hour)
10. Surface application w/incorporation

Biosolids Uses:

- Class A Unrestricted Use allows for use on lawns & gardens, as long at the following standards are met: Table III metals, Class A Pathogen Criteria, one of the VAR options 1-8 for Treatment

- Class A Restricted Use allows for some lawn and garden use, as long the following standards are met: exceeds Table III Metals Limits (but still within Table 1), Class A

Pathogen criteria, one of the VAR for Treatment, and is subject to annual pollutant loading limits (APLR)

- Class B Restricted Use (agricultural)

Appendix E: Photos from Demonstration Project

Site: Pre and Post Installation

Site before BioBeetle Installation

Site after BioBeetle installation

Types of Waste

Sludge Cake

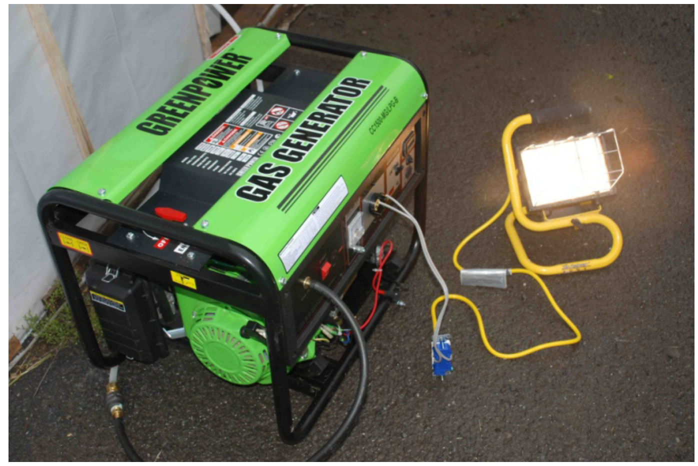
Bakery Waste

Produce Waste

Household Waste

Biogas Generation

Biogas being flared at night



Biogas creating electric power

BioBeetle System Picture

Front-End of BioBeetle with Garb-El Grinder

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Proof-of-Concept for Co-Digestion of Food Waste, Fats, Oil and Grease, and Wastewater Sludge Cake to Create Renewable Energy

Final Report
August 2012

State of New York
Andrew M. Cuomo, Governor

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