Technology Market Summit
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Case Study Primer for Participant Discussion: Biodigesters and Biogas

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Executive Summary

Anaerobic digestion is a biological process in which bacteria break down organic matter in the absence of oxygen. A biodigester or digester is an airtight chamber in which anaerobic digestion of manure, biosolids, food waste, other organic wastewater streams or a combination of these feedstocks occurs. This process produces commodities such as biogas (a blend of methane and carbon dioxide), animal bedding, and fertilizer. Digesters have been used commercially for over 30 years and are currently found in the agricultural, wastewater treatment, and food waste management sectors.

There are multiple designs for the digesters themselves, depending on the facility's location, feedstock, and goals. Benefits of digesters include reduced greenhouse gas emissions, renewable energy production, potential water pollution control opportunities, and financial savings or additional revenue streams. Despite their potential to address pressing environmental concerns and generate revenue, digester use is not widespread in the U.S.

Barriers to widespread digester use include:

- High capital costs
- Investor risk associated with low prices for biogas
- Variability in feedstock and byproduct markets
- Variability in carbon offset and credit markets
- State by state regulation for digester operations and byproducts

Solutions to increase digester use in the U.S. include:

- Education on the benefits and potential uses of digesters, especially for state and local officials
- Commercialization of nutrient reduction technologies
- Local regulations that foster digester use
- Regulations requiring the diversion of organic waste from landfills
- Stable markets for carbon offsets
- Creation of a national Renewable Portfolio Standard that includes biogas
- Promotion of biogas as a domestic renewable energy source by Federal agencies
- Municipal development of digesters (across all sectors) as a service to the community
- Private-public partnerships that support digester projects
- Community models for project design and investment
- Additional research on effluent constituents and values

Digester projects may be eligible to sell renewable energy credits (RECs) and/or carbon offsets, which can improve project economics. Other financial incentives, such as loan guarantees or grant programs, may be available for constructing and utilizing digesters.

There are a variety of models for ownership, financing, and the recovery and use of byproducts, which this primer will discuss.

Introduction

The U. S. Environmental Protection Agency is committed to exploring environmental technology opportunities that cooperatively engage the investment, business, technology, government, nonprofit and academic communities. EPA's roadmap, Technology Innovation for Environmental and Economic Progress[1], outlines EPA's vision:

> *The EPA will promote innovation that eliminates or significantly reduces the use of toxic substances and exposure to pollutants in the environment and that also promotes growth of the American economy. Building upon the EPA's history of scientific and technological expertise, the Agency will seek out prospective technological advances that have the greatest potential to achieve multiple environmental goals. Consistent with its statutory and regulatory authorities, the EPA will partner with a diverse set of new and existing stakeholders to speed the design, development and deployment of the next generation of environmental technologies, creating a cleaner environment and a stronger economy for our nation and the world.*

The Technology Market Summit on May 14, 2012 supports EPA's vision by bringing together representatives of diverse sectors to come up with ideas and actions to support a cleaner environment, new technology markets, and new jobs. The Summit is designed to yield specific, short and long term steps that government, business, nonprofit and academic communities can take to facilitate private investment in sustainable environmental technologies.

The Summit provides participants with the opportunity to engage in dialogue on one of three case studies: fenceline air quality monitoring, the automotive supply chain, and biodigesters and biogas.

This primer serves as a foundation and guide for discussions on anaerobic digesters, their associated technologies, and the potential to expand their adoption. This topic that has been identified as having significant potential for advancing environmental improvements through innovative business and investment models. The case study focuses on the use of anaerobic digesters in America's agricultural, wastewater treatment, and food waste management sectors. Either through direct application of existing digester technology or when paired with new innovative technologies, anaerobic digesters can help address climate change, promote energy independence, and reduce non-point source pollution in the nation's waterways.

Definitions and Background

A digester is an airtight chamber in which anaerobic digestion occurs and biogas is produced. The terms "anaerobic digester" or "biodigester" are used interchangeably and may be used to refer to the entire biogas recovery system. Digesters also reduce volatile organic solids and the number of disease-causing microorganisms in solids.

Anaerobic digestion is a biological process in which bacteria break down organic matter in the absence of oxygen. One of the products of anaerobic digestion is biogas, which typically contains between 50 to 70 percent methane, 30 to 40 percent carbon dioxide, and trace amounts of other gases. Methane is a potent greenhouse gas (GHG), 21 times more powerful than carbon dioxide.

- Anaerobic digestion is the same process that occurs within most open organic wastewater lagoons. Use of a biogas control system brings the added benefits of gas capture and increased efficiency of biogas production.
- The amount of products (e.g. methane) produced in a digester depends on the size of the digester and the feedstock composition.

[1] Technology Innovation for Environmental and Economic Progress: An EPA Roadmap, available at http://www.epa.gov/envirofinance/innovation.html.

Anaerobic digesters and biogas recovery systems are already part of common public and private infrastructure, including municipal and private wastewater treatment, agricultural operations, and food and organic waste management.

Biogas can be used as a fuel to generate electricity and mechanical energy, as a boiler fuel for steam production, space or water heating, or upgraded to natural gas for pipeline injection or for vehicle fuel (compressed natural gas (CNG) and liquefied natural gas (LNG)). Flares are also installed to eliminate extra gas and as a back-up mechanism for the primary gas use device. Regardless of the type of device, control of biogas emissions leads to significant reductions in greenhouse gas emissions.

The solid material remaining after anaerobic digestion may be referred to as “separated solids” (in the agricultural context) or “biosolids” (in the wastewater context). It may be used to produce marketable byproducts such as fertilizer, soil amendments, compost, livestock bedding, alternative energy sources, and other products. Supernatant is the liquid that is separated from the solids and usually sent back to the wastewater treatment plant (WWTP). Supernatant is rich in nutrients and some facilities use a process to extract phosphorus from supernatant, which may then be sold as a fertilizer product. In the agricultural context, the separated liquid is referred to as “digestate” or “liquid effluent.”

Wastewater Treatment Plants (WWTP)

The primary purpose of anaerobic digesters at municipal WWTPs is to reduce the volume of volatile organic solids, remove pathogens, and stabilize sewage sludge for subsequent land application or disposal. In some industrial applications, such as breweries, the entire wastewater stream may be treated anaerobically to produce biogas as a pretreatment process before discharging to a municipal sewer. This is in contrast to municipal operations, where typically only the sewage sludge generated by the wastewater treatment process is digested. These types of industrial wastewater streams typically contain much higher loads of organic material than municipal wastewater, making anaerobic wastewater treatment viable.

There are 3,171 WWTP with flows greater than one million gallons per day (MGD) in the U.S.[2] One estimate places the number of WWTP with digesters between 1,455 and 1,484.[3] However, the data for this count is uncertain. The Water Environment Federation is currently conducting a study to collect updated data on the number of treatment plants with digesters and what they do with the biogas they produce. One study estimates that approximately two percent of centralized WWTPs with anaerobic digesters generate energy from digester gas.[4] As with the count of wastewater digesters, data for this is uncertain and is the focus of current data collection efforts.

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[2] U.S. EPA Combined Heat and Power Partnership. *Opportunities for Combined Heat and Power at Wastewater Treatment Facilities: Market analysis and Lessons from the Field.* October 2011. p. 8.

[3] Ibid, p. 5 and 8. There are 1,351 WWTPs that operate an aerobic digester but do not utilize a CHP system. There are 133 WWTPs that use CHP; 104 of which utilize digester gas as the primary fuel source. The CHP systems that use a different primary fuel source either do so because they do not operate anaerobic digesters or biogas is not a feasible option. The report does not breakdown how many WWTPs with CHP systems operate digesters.

[4] Bullard, C.M. et al. *Seasonal and Lifecycle Cost Considerations in Evaluating Beneficial Utilization of Digester Gas.* 2009. Available at: http://www.ohiowea.org/docs/Beneficial_Use_of_Digester_Gas.pdf

Some WWTPs have excess digester capacity and therefore offer the opportunity to co-digest food waste, fats, oils, and grease (FOG) and/or other high strength wastes. Enhancing the production of biogas with FOG and/or food waste can provide a renewable energy source with existing infrastructure while diverting valuable resources from landfills and reducing sewer conveyance burdens. The rate at which material is added to the digester must be carefully controlled in order to get maximum yields from co-digestion with high strength waste. High strength waste produces higher biogas generation but presents some challenges with dewatering and disposing of the increased sludge. Additional feedstocks, especially food waste, are often eligible for financial assistance through the sale of carbon credits.

Another benefit to digesters is their ability to transform aircraft de-icing fluid (ADF). Post application to planes in inclement weather, ADF cannot be directly discharged to waters because it has a very high dissolved oxygen consumption rate. Further, it cannot be recycled and re-applied to planes; only virgin product meets FAA guidelines. Typically, this material is collected and stored on site and then discharged slowly into the sewer system or trucked to specific treatment plants. However, a new method of treatment introduced by Professor Daniel Zitomer at Marquette University injects ADF directly into anaerobic digesters. Degradation by this process requires much less energy than treating it in a typical WWTP, and the fermentation of ADF produces methane gas, a useful by-product.

WWTP Work

East Bay Municipal Utility District (EBMUD) in Oakland, CA is a public water utility that currently produces about 90 percent of its energy onsite by utilizing food waste to fill excess digester capacity at the WWTP.[1] The facility recently added a 4.6 MW turbine and now produces more power than needed for its own operations, enough to power more than 13,000 homes. EBMUD exports excess electricity back to the grid. Today, EBMUD serves 650,000 customers, treats an average 70 MGD of wastewater and produces approximately seven MW of renewable energy. (http://www.wateronline.com/article.mvc/Waste-To-Power-Program-Becomes-Blueprint-For-0001?sectionCode=News&templateCode=SponsorHeader&user=560267&source=nl:33651) (Note that this facility's additional capacity far exceeds most other plants because these digesters were built to handle large quantities of wastes from the fishing and canning industries, which have since collapsed.)

In Millbrae, California, FOG is being co-digested to meet 80% of the WWTP's energy needs. Millbrae has increased biogas production by nearly 100%, reducing its utility energy bill by 75-80%, preventing some 589 tons of GHG from being emitted into the atmosphere annually, and reducing annual dewatered biosolids hauling by 35%.

The April 2007 EPA Combined Heat and Power (CHP) Partnership report, "Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities (WWTF)," concluded that:

1. For each 4.5 MGD processed by a WWTP with anaerobic digestion, the generated biogas can produce approximately 100 kilowatts (kW) of electricity.
2. The 2004 Clean Watershed Needs Survey (CWNS) identified 10,107 MGD of wastewater flow at facilities greater than five MGD that have anaerobic digestion but no biogas utilization. If these facilities were to employ a CHP system, approximately 225 megawatts (MW) of electric capacity could be produced.
3. Using CWNS data, a total of 2.3 million metric tons of carbon dioxide emission reductions can be achieved annually through increased use of CHP at WWTPs. These reductions are equivalent to planting approximately 640,000 acres of forest, or the emissions of approximately 430,000 cars.

The October 2011 EPA CHP Partnership report, "Opportunities for Combined Heat and Power at Wastewater Treatment Facilities: Market Analysis and Lessons from the Field," concluded that:

- While many WWTPs have implemented CHP, the potential still exists to use more CHP based on technical and economic benefits. As of June 2011, CHP systems using biogas were in place at 104

WWTPs, representing 248 MW of capacity. CHP is technically feasible at 1,351 additional sites and economically attractive (i.e., payback of seven years or less) at between 257 and 662 of those sites.

- On a national scale, the technical potential for additional CHP at WWTPs is over 400 MW of biogas-based electricity generating capacity and approximately 38,000 MMBtu/day of thermal energy. This capacity could prevent approximately three million metric tons of carbon dioxide emissions annually, equivalent to the yearly emissions of approximately 596,000 passenger vehicles.

Livestock Manure Digesters

Anaerobic digesters may be used in dairy, beef, swine, or poultry operations as an added improvement to traditional waste management systems such as manure storage and lagoons. Anaerobic digesters are particularly effective in stabilizing manure and reducing methane emissions but can also provide other air and water pollution control opportunities, as well as opportunities for financial savings or additional revenue streams.

There are currently 186 digesters utilized in commercial agricultural operations in the U.S.[5] About 30 percent of these digesters co-digest other feedstocks with manure. There are a growing number of community digesters that have received USDA funding support and are co-digesting food waste, FOGs, and septage in addition to manure.

Digesters have the potential to improve nutrient management, as compared to managing nutrients through the spreading of raw manure. Additionally, nutrients may be recovered from digester effluent and transported off-site.

Dairy Digesters

Clear Horizons, LLC owns, operates, and maintains a digester and electricity generation equipment at Crave Brothers Dairy. The system utilizes cogeneration to run the digester, and also co-digests whey and cheese plant waste from on-site operations. The digester can be operated and monitored remotely using an Internet-linked workstation. In return for operating the system, Clear Horizons retains the rights to the separated solids and environmental attributes associated with the digester. The farm buys solids back from Clear Horizons for use as bedding and keeps nutrient-rich liquid for land application.

A project is underway at Fair Oaks Dairy in Jasper, IN to power the dairy's fleet vehicles with CNG produced from one of the farm's digesters.

Biogas recovery systems at livestock operations can be a cost-effective source of clean, renewable energy that reduces greenhouse gas emissions. The potential biogas recovery estimated for 8,200 U.S. dairy and swine operations is more than 13 million megawatt-hours (MWh) per year, replacing about 1,670 MW of fossil fuel-fired generation. Additionally, biogas recovery systems may be feasible at some poultry and beef lot operations as new and improved technologies for these types of operations enter the market. [6]

[5] http://www.epa.gov/agstar/projects/index.html
[6] http://www.epa.gov/agstar/tools/market-oppt.html

Food Waste Digesters

Food waste is the number one material disposed in landfills in the U.S. (over 33 million tons disposed annually) and has high methane production potential.[7] If 50% of the food waste generated each year in the U.S. was anaerobically digested, enough electricity would be generated to power over 2.5 million homes for one year.[8] The disposal of food waste via a kitchen garbage can has a substantial carbon foot print, truck to landfill. However, the disposal of the same material using a food waste disposer has a lower carbon foot print, and in the case where the wastewater treatment plant has anaerobic digestion followed by a CHP facility, the carbon foot print is zero[9]. Food waste can be either pre-consumer (e.g., prep waste, brewery waste, dairy waste, cannery waste, slaughterhouse waste, fats, oils, greases, etc.) or post-consumer waste (e.g. table scraps, restaurant leftovers, etc.). Certain industrial wastes, such as glycerol (a byproduct of biodiesel production) are also digestible in all types of digesters but are sometimes included in the food waste category.

Food waste can be co-digested at WWTPs, livestock digesters, or digested alone. There are currently only a few WWTPs around the country using co-digestion, although these projects have demonstrated potential. Agricultural digesters (AD) tend to use food waste materials from industrial generators that can be consistently supplied, such as whey or off-spec yogurt. There is currently only one stand-alone food digester in the U.S., although there are several additional projects in development in the U.S. as well as existing projects outside the country.

Food Waste Digesters

The University of Wisconsin, Oshkosh owns and operates a demonstration scale (10,000 tons per year (TPY) capacity) dry fermentation anaerobic digester that processes source separated food waste and yard trimmings. The CHP system is projected to produce eight percent of the campus's electricity needs and heats adjacent buildings. (http://www.jgpress.com/biocycleenergy/sitetours.html)

A commercial scale dry system (30,000 TPY) owned and operated by a subsidiary of U.S.-based Harvest Power, Inc. is nearing completion near Vancouver, BC and will commence operations in 2012. Harvest Power is also scheduled to begin operation of a 70,000 TPY wet fermentation system this year in London, Ontario that will process pre- and post-consumer food waste and fats, oils, and grease.

In Columbia, SC, W2E Organic Power is permitted to construct an anaerobic digestion facility to process pre- and post-consumer food waste, solid and liquid grease, and some yard trimmings. The waste will be sourced from a variety of commercial waste generators, including produce markets, health care systems, Quest Recycling, Walmart, and a food bank. Electricity produced by the digester will be fed into the grid and purchased by South Carolina's state owned electric and water utility. The State Department of Health and Environmental Control granted a solid waste permit for the facility. (http://www.jgpress.com/archives/_free/002445.html, http://www.columbiabusinessreport.com/news/37706-dhec-approves-permit-for-waste-to-energy-plant)

Cottonwood Dairy at Gallo Farms in Merced County, CA previously utilized wastewater lagoons to manage manure from the farm and wastewater from the on-site cheese processing plant. The dairy installed an anaerobic digester which now processes each of these waste streams, producing electricity and waste heat that are utilized on-site, with excess electricity being sold to Pacific Gas & Electric through a net-metering contract. This project has also generated more than 66,000 carbon offsets through the Climate Action Reserve. (https://thereserve1.apx.com/mymodule/reg/prjView.asp?id1=393 or https://thereserve2.apx.com/mymodule/reg/prjView.asp?id1=393)

[7] http://www.epa.gov/osw/conserve/materials/organics/food/fd-basic.htm
[8] http://www.epa.gov/region9/waste/features/foodtoenergy/
[9] Life Cycle Assessment of Systems for the Management and Disposal of Food Waste. Prepared for Emerson Appliance Solutions and InSinkErator by PEAmericas. February 28, 2011

Current State of Digester Technology

There are multiple types of configurations and designs for digesters.

- Anaerobic digestion can be performed in batches, where the feedstock is added at the beginning of the process and the digester is then sealed for the duration of the process, or, more commonly, as a continuous process in which biomass is constantly added or added in stages.
- Digesters can operate at ambient temperature (psychrophilic), mesophilic ranges (in temperatures of 25-38 degrees Celsius/77-100 degrees Fahrenheit) or thermophilic ranges (39-65 degrees Celsius/102-149 degrees Fahrenheit).Thermophilic digesters have greater pathogen reduction and meet Class A biosolids standards; however, they are more difficult and more expensive to maintain.
- Digesters are designed to process feedstocks of either high or low solids content, and may be dry digesters that process high solids without the addition of water or wet digesters that process high or low solids with the addition of water.
    - Low solids (wet) digesters are common at WWTPs and agricultural digesters (AD). These typically have two to three percent solids content in the wastewater context, with ranges as high as six to eight percent solids content. Livestock manure digesters usually operate with wastewaters in the range of 0.5 to 14 percent solids content.
    - High solids fermentation systems (dry digesters) are less common in the United States but are common in Europe for food waste digestion and other high-strength solids.
- Common digester types include Plug Flow, Complete Mix, Covered Lagoon, and Fixed Film Digesters (also known as an Attached Media Digester). These are used in agricultural applications as well as in municipal wastewater treatment for sludge digestion. Additional digester types used in wastewater treatment to treat the entire wastewater stream include Up-flow Anaerobic Sludge Blanket or Induced Blanket Reactors and Anaerobic Filters.

Nutrient management is applicable in both the agricultural and wastewater contexts, and nutrient reduction following anaerobic digestion is becoming increasingly common. New processes and methods for separating and recovering nutrients are emerging.

Agricultural operations must carefully manage nutrients in manure storage and during land application of manure. Anaerobic digestion presents an opportunity to, at minimum, improve storage processes for manure, and at best and when combined with other technologies, to recover nutrients in a marketable form where they may be transported and sold off-site. The process can reduce nutrient loading on soils which have reached their maximum potential for nutrient utilization. Nutrient recovery in agricultural digesters (ADs) is typically executed by separating the solids from the liquid effluent. This may be done using a centrifuge, heat-drying, or a mechanical process such as a screw press. Most farm digester systems in the U.S. do not reduce nutrients further than what is achieved through the physical liquid-solid separation; the degree of nutrient recovery depends on the technique used, and in this case, only addresses the phosphorous component.[10] Physical separation will often provide enough phosphorous removal to meet regulatory requirements.

In wastewater, biological nutrient removal is commonly used for nutrient reduction. The process involves the use of microorganisms under aerobic conditions to remove total nitrogen or total

[10] http://agrienvarchive.ca/bioenergy/nutrient_recycling.html

phosphorous. Biological nitrogen removal involves nitrification – the oxidation of ammonia to nitrite and of nitrite to nitrate – and denitrification – the reduction of nitrate to nitric oxide, nitrous oxide, or nitrogen gas. Phosphorous removal occurs through phosphorous uptake by aerobic bacteria known as phosphate-accumulating organisms.[11]

The formation of struvite, a magnesium ammonium phosphate mineral, can be used to remove phosphorous through chemical precipitation. At some operations, struvite is recovered and formulated for sale as a commercial fertilizer. Although originally applied in the wastewater context, struvite formation and recovery may also be applied to the liquid effluent from agricultural digesters.

Benefits

One output of a digester is biogas. Biogas can be recovered and used to generate electricity for on-site use or sale to the local electric utility. Thermal energy in the form of waste heat, produced during electricity generation, can be recovered to heat digesters or adjacent buildings. Other uses include heat generation by burning biogas in boilers, upgrading biogas to pipeline quality, and converting biogas to compressed natural gas (CNG) for a variety of fuel applications, including vehicle fueling.

In some states, anaerobic digestion projects that generate electricity may be eligible to sell renewable energy certificates (RECs). This may be in the form of "bundled" sales (i.e. selling "green" power at above-market rates) or "unbundled" sales (i.e. selling the electricity at the market rate while separately selling the RECs). It may be possible to sell both RECs and offsets from the same digester because they are crediting different emission reduction activities. The rules and regulations guiding renewable electricity vary by state.[12] RECs may also satisfy regulatory requirements to meet Renewable Portfolio Standards (RPS) in some states; where there is no RPS, RECs may be purchased as part of a voluntary market.

Biogas used as a transportation fuel (as CNG/LNG) is eligible to generate "advanced" Renewable Identification Numbers (RINs), which are tradable credits used for compliance with the Renewable Fuel Standard program. Fuel blenders and other obligated parties are required to generate or purchase a given number of RINs, related to the fuel volumes handled, so the generation of RINs from biogas may provide a significant financial incentive for producers.

Digesters can reduce greenhouse gas emissions through the capture and reuse of methane. Capturing methane emissions that would have otherwise been released without the installation of the digester is an activity that is eligible to generate carbon credits. Currently, there are no regulations in the U.S. that require the control of methane emissions from anaerobic lagoons, so these activities are entirely voluntary. Each metric ton of methane reduced equates to 21 carbon offsets (this does not include any reduced emissions from the generation of electricity from biogas). Anaerobic digestion of livestock manure has been adopted by the State of California as an eligible project type for the generation of offsets under its statewide cap-and-trade program.[13] This means that there is a robust market demand for offsets from dairy and swine manure digester projects.

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[11] http://www.state.nj.us/dep/wms/bwqsa/EPA%20-Biologicl%20nutrient%20removal%20processes&costs.pdf
[12] More information about the different renewable electricity markets and incentives around the U.S. is available at the Database of State Incentives for Renewables and Efficiency: http://www.dsireusa.org/.
[13] http://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm

Digesters also can produce additional products that may generate revenue[14]. For all digester types, the recovery and use of beneficial byproducts may occur through nutrient recovery from digester effluent or supernatant.

- Agricultural digesters (AD) can offset farmers' costs for purchasing bedding for their animals, costs of purchasing fertilizer, and the cost of manure management and spreading.Solids from digesters can be used an alternative to coal in coal-fired power plants, reducing utility costs for compliance with emissions standards.
- Gases produced from digesters can be used to generate electricity on site thus reducing the need to purchase power from the grid.

Finally, digester operators can collect "tipping fees" from farmers and food producers to take their organic waste. Digesters reduce odors and pathogens in manure and wastewater,[15]and on-site cogeneration, or CHP systems, can increase a facility's operational efficiency and decrease energy costs.

Technology

Barriers and Issues

Barriers to biogas production include the following.[16]

- Production of biogas may be highly variable, depending on the consistency with which a digester is "fed".[17]
- Biogas must be treated, or "conditioned", before it is used for fuel or electricity. Conditioning means that moisture and contaminants, including hydrogen sulfide and siloxanes (only found in WWTP biogas), must be removed. The level of treatment depends on the end use of the gas.[18] Treatment for uses such as liquid fuel can be very costly and/or require extensive infrastructure.
- It can be technically and economically difficult for some entities to generate electricity due to utility policies and interconnection challenges, ranging from the cost to installing electric lines with appropriate capacity to the inability of farms to offset their own electricity costs through net metering.
- Even if a utility supports the project, utility lines may have capacity issues. This is a common problem seen with cooperatives in rural areas; the cost to improve the lines must be passed on to all cooperative members. That cost may not be justified based upon the amount of energy produced by the digester operation.
- Connection to natural gas pipelines can be difficult due to proximity to existing pipelines, as well as the costs of equipment necessary to meet strict gas quality and pressure standards.Co-digestion of externally generated organic wastes can allow an operation to generate a larger and more economically viable volume of biogas. However, it increases the volume of nutrients in the

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[14] http://www.epa.gov/agstar/anaerobic/faq.html#q5a
[15] http://www.epa.gov/agstar/anaerobic/faq.html#q5a
[16] The EPA CHP Partnership reports (http://www.epa.gov/chp/publications/index.html) and the Evaluation of Combined Heat and Power Technologies for Wastewater Treatment Facilities (http://water.epa.gov/scitech/wastetech/publications.cfm) report prepared by Brown and Caldwell contain additional and more detailed information about technological barriers to CHP systems in WWTPs.
[17] http://www.nebiosolids.org/uploads/pdf/NE%20Conf.%202010/Lynch-UseBiogas-9Nov10.pdf
[18] Ibid

digestate, and may therefore create additional challenges for the farm with respect to nutrient management.

Barriers to nutrient recovery also exist. Maximum nutrient recovery (beyond solids separation) may be desirable in watersheds with excess nutrients, or for added revenue from byproducts. However, using chemical processes to remove phosphorous or other nutrients from solids can increase operations and maintenance costs. Given the costs and under-developed markets for nutrient byproducts, these technologies are not widely used.

- At Vander Haak Dairy in Lynden, WA, a commercial-scale nutrient recovery process is being piloted.[19] The process recovers additional phosphate and nitrogen from the liquid effluent through ammonia stripping and settling.
- Struvite crystallization, a process used to remove phosphorous from municipal wastewater, can be adapted to dairy and swine operations, but it is expensive and the resulting solids may not be usable for purposes such as cow bedding at dairy operations. There are multiple companies applying or developing this or similar technology.[20]

Solutions

- Co-digestion supplement feedstocks can boost biogas production at smaller facilities.
- Additional options for revenue from digesters are emerging, including the production of biodegradable plastics from waste biogas[21] or separation of the carbon dioxide for its use in nurseries, greenhouses, or other applications.
- There is a growing opportunity for third-party project developers to provide anaerobic digestion to farmers as a service, rather than expecting the farmer to maintain and operate the digester system on their own.
- Other new technologies or developing technologies to capture nutrients in a marketable form are being developed, including micro algae growth. Technologies are in early developmental phases to grow algae on nutrients derived from digester effluent, which would then be recovered and used as biomass for co-digestion and additional feedstock for the digester. These technologies may be applied in wastewater or agricultural digesters.

Market

Barriers and Issues

Potential markets associated with biodigesters include those for the input feedstocks, biogas, value added byproducts, carbon offsets, and RECs. These markets represent independent revenue streams for the owner or operator of the digester.

In many instances, digesters accept materials (food scraps, FOG, waste water treatment sludge, and similar materials) that others regard as waste and would otherwise need to pay disposal or tipping fees. This creates a feedstock market. The local market for disposal of these materials (e.g., landfills or incinerators) creates a market umbrella or upper price that the digester operator can charge for receipt

[19] http://www.tfrec.wsu.edu/pdfs/P1662.pdf
[20] http://www.multiformharvest.com/technology/applications/articles16.php
[21] http://www.mangomaterials.com/about_Us.htm; Another company was working on developing plastics from sewage sludge: http://www.epa.gov/ncer/publications/scienceaction/ncse-micomidas.pdf.

of the feedstock. Generally, the digester will need to charge a discount off the alternative disposal price, so that the total disposal cost to the generator (which includes separation of the organic material and transport to the digester) remains competitive. The tipping fee will often be a significant portion of the revenue stream for a digester operator.

Biogas is another market. Biogas is used to generate heat, energy, electricity, or fuel. The best biogas utilization option for a particular digester system will depend on the value and costs of the biogas end use.

- Electricity – While electricity (either used on-site or sold back to the local utility) is the most common end use of biogas for agricultural digesters, the prices for electricity in most areas are too low to fully finance a digester project.
- Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) – CNG can be burned in modified engines, such as generators or vehicle engines, in place of gasoline or diesel. CNG may prove to be a valuable end use of biogas, especially given the rising costs of gasoline and diesel. Potential users of CNG include fleets such as transit agencies (buses), solid waste agencies (waste hauling vehicles), long haul trucking, dairy operations, local governments, or other fleets. There are barrier costs to converting or purchasing vehicles with bi-fuel engines so CNG made from digester gas typically works best if a local fleet has already converted to fossil-fuel CNG. It is also necessary to establish a consistent

Electricity from Biogas

At the Des Moines Water Reclamation Authority in Iowa surplus digester gas is treated and pressurized on site and sold to a nearby industrial user for direct use as boiler fuel. The boiler has a 1.7 million cubic feet per day (CFD) digester gas capacity and results in $80,000 per month electricity savings. (http://www.cwwga.org/documentlibrary/121_EvaluationCHPTechnologiespreliminary[1].pdf)

The Sacramento Regional Wastewater Control Facility (RWCF) facility supplies treated digester gas to supplement an offsite, natural gas-fueled 80 MW combustion gas turbine CHP facility. Steam produced by the CHP facility (4,800 CFD capacity) is returned to the Sacramento RWCF to meet all of the plant's process and heating needs, and provides standby electrical power. Sacramento RWCF revenue from the adjacent CHP facility is about $600,000/year. (ibid)

CNG & LNG from Biogas

Quasar Energy Group is producing natural gas from biogas, and has three operational fueling stations in Ohio open to public use. They have also converted more than 13 of their fleet vehicles to run on CNG.

The Persigo WWTP in Grand Junction, Colorado has installed two model D24 single tower deliquescent dryers to remove harmful water vapor from digester gas, which has reduced maintenance expenses and improved plant operations. The Persigo WWTP produces approximately 50,000 cubic feet per day (CFD) of digester gas which is used to fuel boilers and generate heat for operations but was flaring excess digester gas at a rate of 100,000 CFD. Excess digester gas is now being converted to compressed natural gas (CNG), which will be used to fuel fleet vehicles and buses for the City of Grand Junction. (http://www.nbc11news.com/home/headlines/Compressed_natural_gas_facility_to_open_in_March_116277229.html ; http://www.gjsentinel.com/news/articles/going_natural ; http://www.cwwga.org/documentlibrary/121_EvaluationCHPTechnologiespreliminary[1].pdf).

Pipeline Injection

Since the early 1980s King County, WA's South WWTP in Renton, WA, has been scrubbing their digester biogas to convert it to natural gas. Using about 20% of the scrubbed gas to fuel the plant's boilers, the WWTP sells the remaining to Puget Sound Energy where it goes into their natural gas pipeline. (https://www.kingcounty.gov/environment/wastewater/ResourceRecovery/Energy/EnergyUse.aspx)

CNG supply in order to make it a reliable revenue source and to attract potential users. Another barrier is the uncertain status of digester gas to qualify for RINs.

- Direct pipeline injection – To be directly injected into utility natural gas pipelines, biogas must be upgraded to higher quality biomethane. This conversion carries high costs in both upfront capital and operating electricity costs. Therefore, although pipeline injection represents steady demand for biogas, it may be cost-prohibitive for smaller digester operations.[22] Another challenge to biogas uses as biomethane and CNG is that natural gas prices are forecasted to decline in future years due to the increase in natural gas supply from shale gas.[23]
- RECs, RINs, and carbon offsets - Biogas recovery systems may potentially receive funding through the sale of carbon offsets or renewable energy certificates. Carbon emissions are not yet directly limited by any U.S. regulatory scheme, thus participation in these markets is fully voluntary. As there is no national carbon trading scheme, there are multiple certification standards for carbon offset credits. Taking full advantage of offsets, whether through voluntary or compliance markets, requires detailed monitoring, reporting and verification.[24] Not all states have renewable portfolio standards; REC prices vary considerably across the U.S.[25] Under the Renewable Fuel Standard (RFS), 40 CFR 80.1426, biogas from landfills, sewage waste treatment plants, or manure digesters that is converted to CNG and then used as a transportation fuel qualifies for RINs.[26]

Solutions

- As some states and municipalities consider limiting or banning organic wastes from landfills, new markets for digesters may emerge as a good alternative for the disposal of these organic wastes.
- As incineration, land filling, and other biosolid disposal options become more expensive in some areas of the country, digesters may be a financially attractive option.
- Some progress is being made at the state level related to RECs and carbon credits. California has passed a statewide cap-and-trade program, and North Carolina's renewable portfolio standard has a specific provision for renewable power from on-farm biogas production.
- Areas of the country with rising energy costs become attractive markets for CHP developers because the higher electricity offset prices lead to shorter payback periods for projects. The market for carbon offsets that are eligible for use in California's compliance program has been growing and maturing. These credits are trading for higher prices than what is currently found in the European carbon markets.
- Public education campaigns promoting biogas, such as those run by the National Ad Council, may raise awareness among the general public and increase demand for renewable gas from utilities.
- Biogas may also be marketed using existing "Buy Local" campaigns to buy local renewable energy. Other byproducts may also be able to be marketed using "Buy Local" themes.

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22 http://www.swrcb.ca.gov/rwqcb5/water_issues/dairies/dairy_program_regs_requirements/final_dairy_digstr_econ_rpt.pdf
23 http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2012).pdf
24 http://epa.gov/agstar/documents/conf11/dubuisson.pdf
25 http://www.epa.gov/chp/state-policy/renewable_fs.html
26 http://www.epa.gov/otaq/fuels/renewablefuels/index.htm

- The creation of standards that help to distinguish carbon offset projects by additional environmental benefits they achieve, such as additional nutrient reductions, may generate interest and encourage development and investment in such projects.

Regulatory

Barriers and Issues

Digesters may be subject to several regulatory requirements, including federal and state permitting for solid wastes, air and water quality. Permitting is generally done at the state level, thus regulations will vary from state to state, creating uncertainty for many developers.[27] WWTP digesters are covered under the plant's NPDES permit and must treat to, at a minimum, the Part 503 requirements for sewage sludge. The addition of FOG, food waste, manure, or other feedstocks into a WWTP's digester results in a mixture that is still regulated as sewage sludge (or biosolids) under the Part 503 requirements.

Local permitting and zoning challenges may exist when installing new digesters. Digester projects may experience the "NIMBY" (Not In My Back Yard) syndrome, in which local communities deny biodigester projects zoning approval out of fears of odors, pollution, increased traffic, or other concerns.

Waste regulations can create uncertainty as to how to handle feed stocks and digestate from digesters, eliciting the following considerations.

- Federal laws do not require solid waste permits for manure application or disposal.
- The acceptance of other organics may designate the digester system as a waste processing facility in some states. Waste processing facilities are required to meet federal regulations under the Resource Conservation and Recovery Act (RCRA) Subtitle D (for non-hazardous solid wastes) and 40 CFR Part 258 (for landfills).[28] RCRA Subtitle D is delegated to state solid waste management programs so solid waste requirements vary from state to state. 40 CFR Part 503 also covers biosolids generated by WWTPs.
- Digesters used in the treatment of sewage sludge need to meet specific operational standards dependent upon the sewage sludge use or disposal method selected and whether the digester is the primary form of treatment used to meet pathogen reduction requirements in 40 CFR Part 503.
- The material processed in privately owned treatment works digesters (such as privately-owned multi-farm digesters) that process food waste, manure, or other feedstocks are subject to state regulation under 40 CFR Part 257 that addresses the land application of non-hazardous solid waste or 40 CFR Part 258 that covers municipal solid waste landfills.
- State solid waste permits for food waste digesters are a new process for many states, thus the permitting requirements and procedures are sometimes unclear.

Air regulations apply for engines and electricity generation.

- In parts of California, strict air regulations for ozone (NOx and VOCs) severely limit NOx emissions from stationary engines. It is currently very costly to meet those standards for engines burning natural gas. This limits biogas use in some areas.

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[27] For an overview of state and federal permitting requirements applicable to agricultural digester systems, see http://www.epa.gov/agstar/tools/permitting.html.

[28] http://www.epa.gov/agstar/tools/permitting.html

- State and local air districts can set emission standards for internal combustion engines. Federal emission standards under the Clean Air Act (40 CFR Part 89) are the minimum threshold, but local standards may be more stringent. These standards include emissions limits for nitrogen oxides (NO_x), hydrocarbons, carbon monoxide (CO), and particulate matter (PM). EPA may certify the engine to meet the standards or the engine manufacturer may provide a "not-to-exceed" guarantee. If the engine is not certified, it is subject to emissions testing, which can cost around $8,000 per year.[29] No engine manufacturers have certified their engines to run on biogas, so all digester systems require testing.
- Micro-turbines and fuel cells typically produce electricity with lower air emissions, but the cost of these systems can be prohibitive.

State water regulations also vary across states but affect digesters by placing limits on the nutrient content of effluent that is discharged or applied on-site at farms.[30]

- Water regulations require dairy and livestock operations to comply with nutrient management plans.
- Wastewater treatment facilities and stand-alone food digesters must get water permits for nutrient issues. Unlike wastewater treatment facilities and dairy operations, stand-alone food digesters could face additional challenges since there is not an existing water permit already at the project.
- Water regulations especially impact digesters utilizing co-digestion, as these digesters add to nutrients on-site. In California, strict water and waste handling regulations limit co-digestion at agricultural operations. Added feedstocks can increase the amount of nutrients that must be disposed of. However, State agencies are attempting to work with the industry to address these obstacles.[31]

Solutions

- At the state level, increased education on the value of biogas production and use, as well as increased awareness of the challenges posed by the current regulatory scheme, may help make the case for improved and streamlined permitting requirements and increased government support for digester projects.
    - Ohio recently passed House Bill 276 which confirms that a farm that uses technology (like a digester) will not lose its agricultural treatment for zoning or current agricultural use value (CAUV) as long as the energy produced is secondary to the farm's operations and at least 50 percent of the feedstock was from that farm.[32] This legislation is an example of the state preventing local permitting and zoning from prohibiting the installation of an agricultural digester. Similar legislation could be encouraged in other states to address this issue.
    - Many states have Renewable Portfolio Standards (RPS) or Goals, which require that utilities generate a specified percent of electricity from renewable resources. These standards vary on the amount of renewable energy they require, the specificity of the composition of the sources of the renewable energy, and the date by which the target

[29] Ibid
[30] Personal communication with EPA staff.
[31] See presentations of Tuesday, March 15, 2011: "Special Topics Series: A Path Forward for Dairy Digesters in CA": http://www.climateactionreserve.org/resources/presentations/
[32] http://www.lsc.state.oh.us/fiscal/fiscalnotes/129ga/hb0276en.pdf

must be achieved. More stringent portfolio requirements may increase demand for renewable energy projects such as digesters.[33]

- The creation of a National Renewable Portfolio Standard (RPS) and the inclusion of biogas in such a standard would increase demand for energy generated from biogas. The challenge to implementing a national RPS is that the mandate could push the price of biogas too high to make producing biofuels from biogas feasible and could have negative effects on the market for biofuels.
- Regulatory schemes for nutrient management may impact the development and use of nutrient reduction technologies in conjunction with digesters. A nutrient trading scheme could create incentives to recover nutrients from digestate by increasing the value of those nutrients as byproducts.

Investment/Finance

Barriers and Issues

Securing funding for upfront capital costs of a digester system or loan guarantees can prove to be the primary obstacle to installing a digester, particularly for small farms and other businesses. Digesters cannot usually be used as collateral for loans because they do not have an after-market or resale value. In addition, uncertainty in market prices for biogas, byproducts, and emission credits create challenges to assuring a reasonable payback period for digester projects. Private investors face risk and uncertainty from regulatory schemes, underdeveloped markets for end products and byproducts, and volatile energy prices.

Technologies that complement digester systems and that may provide additional sources of revenue, such as nutrient recovery technologies, face a funding gap when transitioning from a pilot phase to commercially available phase.

Current government incentives have been used for some projects. However, the future of these funds is uncertain. New business models need to be developed that do not rely on government intervention in the market to deliver a reasonable payback period for investors, although government loans and loan guarantees may help secure local bank loans for digester projects.

- Agricultural digesters used for electricity generation may be eligible for loan guarantees and grants under programs such as the Rural Energy for America Program (REAP) and the Environmental Quality Incentives Program (EQIP) under the Farm Bill. They may also qualify for Production Tax Credits and Investment Tax Credits under the Energy Policy Act of 2005.
- Digesters used to produce renewable natural gas may be eligible for biorefinery development grants under the Farm Bill.
- Digesters used to produce CNG may be eligible for biomass-based diesel production credits under the Energy Policy Act of 2005 and for grants under the Department of Energy State Energy Program.
- Digester projects producing CNG or LNG from biogas derived from food waste are not currently eligible for RINS.
- State Revolving Loan Funds (SRFs) can be used for improvements at wastewater treatment plants, including the installation of anaerobic digesters or CHP units.

[33] http://www.epa.gov/chp/state-policy/renewable_fs.html, http://www.dsireusa.org/rpsdata/index.cfm

Solutions

- Improving regulatory certainty may help increase security for investors.
- States are neither limited nor required to fund digester projects through SRFs. Therefore, EPA or states could develop ways to prioritize funding for digester projects due to the multiple environmental benefits they provide, including energy conservation and, in the case of co-digestion, solid waste reduction.
- The American Recovery and Reinvestment Act (ARRA) of 2009 established a "Green Project Reserve" for SRFs, requiring that a portion of all awarded funds be set aside for projects meeting certain environmental criteria. This was a way to emphasize that ADs can be used at WWTPs for energy recovery, not just material reduction, and could be used as a model set-aside mechanism for other funds.[34] This requirement was carried over in 2010 and 2011.
- Anaerobic digesters at a municipal wastewater treatment facility would generally be eligible for tax-exempt bond financing. Normal restrictions to tax incentives would apply, such as that the asset must be owned by a public sector entity. If the asset is privately financed or operated, it can still be financed with tax exempt bonds if the private company seeks and receives a private activity bond volume cap from the state.
- Various states with clean energy departments or programs are beginning to consider AD projects in current RFPs.
- State grants for water quality and nutrient management present potential opportunities for individual digester project financing.
- Local governments can own and/or operate ADs, not just traditional WWTP digesters or municipal waste digesters. Digesters for livestock manure that are owned, operated, or developed by municipalities or counties can address overarching environmental concerns, such as water quality issues due to nutrients in agricultural runoff.
- Private-public partnerships may create innovative cost-sharing models that spread risk and reward more evenly among project funders, developers, and owners. Private companies have partnered with municipalities to build and maintain digesters and biogas-to-energy systems. There are multiple private companies in all of the sectors that offer third-party build-own-operate business models. Private companies may be able to use high credit ratings to secure more favorable loan terms than small operations or municipalities.
- Corporate social responsibility campaigns or carbon-neutral commitments can provide an impetus for private companies to invest in digester projects or sign long-term contracts providing revenue to digester projects.
- Investment funds or foundations with commitments to environmental or community projects could be targeted for funding for digester projects. Impact investors could provide upfront capital as a program or mission related investment. Impact investors would lend to projects at or below market interest rates and, in return, enable the environmental benefits provided by biogas.

[34] http://www.gefa.org/index.aspx?page=525

Case Studies

Photo I: Courtesy of Marc Deshusses

Tapping into Corporate Commitments: Duke University, Duke Energy, and Google – Swine Waste Digester at Loyd Ray Farms

Duke University, Duke Energy, and Google collaborated to build, design, operate, and finance an innovative waste-to-energy system on a swine farm in Yadkin County, North Carolina. The swine farm, on Loyd Ray Farms, houses an anaerobic digester that processes hog waste, formerly stored in open lagoons and sprayed on farm fields. The methane generated from the digester is collected and then used to power a 65-kw microturbine, which produces electricity to power the waste management system at the farm. The effluent from the digester flows by gravity to an aeration basin, which further cleans the wastewater. The digester and basin together substantially eliminate nutrients, ammonia, odors, pathogens and heavy metals, allowing the farm to meet the stringent standards required for projects receiving funding from the state's Lagoon Conversion Program.[35] Because both basins are lined with heavy plastic, discharge of waste to surface and ground water is prevented.

[35] The specific permit requirements for Loyd Ray Farm's Innovative Waste Management System are as follows:

1. **Substantially reduce ammonia:** Combined ammonia emissions from swine waste treatment and storage structures may not exceed an annual average of 0.2 kg NH3-N/week/1,000 kg of steady state live weight (SSLW) or 106 kg NH3-N/week for this facility. Ammonia emissions from land application sites shall not exceed an annual average of 0.2 kg NH3-N/week/1,000 kg of SSLW or 106 kg NH3-N/week for this facility. Total ammonia emissions from the swine farm must not exceed an annual average of 0.9 kg NH3-N/week/1,000 kg or SSLW or 476 kg NH3-N/week for this facility.
2. **Substantially reduce odor emissions:** All instantaneous observed odor levels shall be less than the equivalent of 225 PPM n-butanol.
3. **Substantially eliminate the release of disease-transmitting vectors and airborne pathogens.** Fecal coliform concentrations in the final liquid effluent shall not exceed an annual average of 7,000 Most Probable Number/100 mL. .Separated solids and biological residuals = vector attraction reduction requirements in 15A NCAC 02T .1107. System shall meet the pathogen reduction requirements in 15A NCAC 02T .1106 for Class A biosolids to be land applied on-site pursuant to .1106(a)(1) or for Class B biosolids that are to be otherwise land applied.
4. **Substantially eliminate nutrient and heavy metal contamination of soil and groundwater:** Meet the current NRCS requirements for a Comprehensive Nutrient Management Plan (CNMP) as defined by Part 600, Subpart E of the NRCS National Planning Procedures Handbook; and Demonstrate through

The Duke project is notable due to its additional pollution reduction benefits and its financing mechanisms. The liquid effluent from the digester is sent to an aeration basin and treated to remove ammonia and other pollutants. The treated effluent is then re-used for barn flushing. Moreover, whereas farmer Loyd Bryant formerly grew only low-value grass and millet that could absorb the high nutrient content in the effluent, he will soon be able to use those spray-fields to plant cash crops such as wheat, corn, and beans. This system makes it possible for the farm to meet state standards for odors, ammonia, nutrients, pathogens, and metals that would be demanded of a new or expanded farm. These systems also qualified the project for a combined grant of $500,000 from the North Carolina Lagoon Conversion Program and the federal Natural Resources Conservation Service. By meeting innovative waste management standards, it is possible for the farm to expand. Other economic benefits include expected reduction in animal mortalities, as replacing lagoon effluent with clean water from the aeration basin to flush the barns will improve air quality in the barns.

Photo II: Courtesy of Tatjana Vujic

In addition to state and federal grants, the project is financed through Duke University, Duke Energy, and, most recently, Google. Duke University and Duke Energy financed initial construction costs and will divide operations and maintenance costs for the first ten years of the anaerobic digester operations. Google has joined the partnership to share the burden of Duke University's operating costs for the first five years. Duke University and Google realize benefits through their receipt of credit for the greenhouse gas emission reductions (or carbon offsets from methane capture) achieved by the project, which will help each institution meet its goals of carbon neutrality. Duke Energy also receives renewable energy certificates (RECs) that it counts towards its state mandate to generate 0.07 percent of its electricity from hog waste. This state mandate became effective in 2012, and the requirement will increase to 0.20 percent in 2018. In year ten, Duke University and Duke Energy will have a right of first refusal to purchase carbon offsets and RECs generated by the system. The project required no financial investment directly from Loyd Ray Farms.

The Loyd Ray Farms digester project represents a win-win situation for all parties involved. It helps the farm manage waste, reduces its electricity costs, and potentially reduce animal mortalities, and it opens up new planting options at no cost to the farm. It provides Duke Energy with the RECs it needs to meet its renewable energy portfolio requirements, and provides Duke University and Google with verified carbon offsets.[36]

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predictive calculations or modeling that land application of swine waste at the proposed rate will not cause or contribute to a violation of groundwater standards under 15A NCAC 02L.

[36] The carbon offsets will be registered and verified to the Climate Action Reserve's Livestock Methane Protocol, which has been recognized by the California Air Resources Board, the entity that manages the state's cap-and-trade program.

Duke University and its partners are optimistic that installation of this system and other biodigester-based systems will become widespread. However, the reality is that this project was largely possible because state and federal grant opportunities encouraged the partners to move forward by lowering up-front capital costs. Nevertheless, the Loyd Ray Farms digester project has already provided valuable lessons about cost sharing, system design, cost reductions, market payments, and new farm income streams that should prove powerful in helping to make digester systems accessible in the future.

For more information, see:

- The Loyd Ray Farms Swine Waste-to-Energy Project. Sustainable Duke Carbon Offsets Initiative. http://sustainability.duke.edu/carbon_offsets/Projects/loydray.html .
- Henderson, Bruce. "Pig waste proves powerful." *The Charlotte Observer.* October 26, 2011. Available at: http://www.charlotteobserver.com/2011/10/26/2725630/pig-waste-proves-powerful.html#storylink=cpy.
- Simmons, Gus, P.E. Cavanaugh & Associates. Digester Systems for Animal Waste Solids – The Loyd Ray Farms Project. PENC December Seminar, December 2011, Raleigh NC. Available at: http://www.penc.org/Files/2011/2011-Raleigh-Conference/Loyd-Farm-Presentation-12-15-2011.aspx.
- Zucchino, David. "A farm lives high – and clean – off the hog." *The Los Angeles Times.* December 25, 2011. Available at: http://articles.latimes.com/2011/dec/25/nation/la-na-hogs-waste-20111225.
- "Sometimes greening Google means getting a little dirty." Google Green Blog. Available at: http://googlegreenblog.blogspot.com/2011/09/sometimes-greening-google-means-getting.html

Teaming Up for Success: Ameresco and Philadelphia Water Department – Northeast Water Pollution Control Plant Biogas Project

The Philadelphia Water Department (PWD), Ameresco, Inc., and Bank of America Merrill Lynch entered into a private-public partnership in which Ameresco will design, build, and maintain a biogas-to-energy system, Bank of America owns and PWD operates the facility. The facility is located at the city's Northeast Water Pollution Control Plant (NEWPCP). The new CHP system will allow PWD to harvest the energy contained within the biogas generated by its anaerobic digesters. Currently the digester gas is used to heat water on an annual basis; approximately half of it is excess and therefore flared. Electricity and thermal energy generated from the system will be used on-site to heat the digesters and produce up to 85% of the electrical power needs of the treatment plant. The capital project will leverage the plant's current systems, including the eight existing digesters, a gas storage vessel, existing heat loop system for heating digester and other campus buildings, and the flare system to be used as back up. Minimal modifications are needed to existing equipment. The development of this biogas co-generation project is expected to reduce PWD's operating costs by approximately $12 million over the course of the 16 year contract.

Under a 16 year contract, PWD will provide lease payments to Bank of America Merrill Lynch. At the end of the contract, PWD will have the option of renewing the lease, purchasing the cogeneration system at fair market value, or terminating the arrangement outright. A separate but related agreement has been established under which Ameresco provides maintenance services for the duration of the lease term. The total construction cost of the facility is $47.5 million, including $2.5M for the cost of design which was immediately transferred to the City. The remaining costs, because the equipment and structures are owned by a private entity, qualify for an investment tax credit worth approximately $13 million through the American Recovery and Reinvestment Act.[37] The partnership represents a novel financing approach that allows the municipality to utilize new and innovative technology without shouldering the capital costs up-front while gaining the advantage of an experienced developer.

Obtaining capital for non-mission critical work, as energy production or conservation projects are often defined, can be particularly challenging for public wastewater utilities. Ameresco was required to develop an Economic Opportunity Plan as part of the contract award and expects the project to bring new green jobs to Philadelphia. All of this reveals that public-private partnerships have financial, legal, engineering, social and political elements that must be considered and managed.

The system construction is due to be completed in May 2013 and completely operational by summer 2013. Parts of the system will last much longer than the 16-year contract. The engines have an expected life span of over 20 years, if maintained in accordance with the manufacturer's specifications, and the building and piping system could last as long as 50-100 years. The agreement with Ameresco allows PWD to leverage existing infrastructure for the capture of energy and/or the development of additional sources. The biogas co-generation facility acts as a kind of foundational stepping stone, allowing for not only these opportunities but also the chance for a change of ethos.

[37] The ITC, under Section 48, allows businesses and individuals to take a one-time, upfront tax credit equal to 30 percent of the investment in solar energy, wind energy and certain other types of renewables. The ITC only applies to qualified facilities placed in service after December 31, 2008, and before Dec. 31, 2013. The NEWPCP Biogas Project qualified for the ITC as a renewable energy project owned by a private entity but leased to a public, tax-exempt entity; however, the qualifications for the ITC have been revised and this form of private-public partnership would not be allowable under new standards.

For more information, see:

- http://www.ameresco.com/press/ameresco-and-philadelphia-water-department-announce-northeast-water-pollution-control-plant
- http://www.biocycle.net/2012/03/anaerobic-digestion/
- http://www.energyboom.com/policy/government-extends-arra-itc-provision-include-grants

Addressing Water Quality Issues with Biodigesters: Dane County Centralized Manure Digester

The Dane County Community digester is a biogas energy system that utilizes manure from three local dairy farms to generate energy and manage farm waste for nutrient content. The system is owned and operated by developer Clear Horizons, LLC. The project has allowed the participating farms to achieve economies of scale and benefits they would not realize working independently. The project also addresses a significant water quality and pollution issue in the Dane County, WI area. The County's objective to improve water quality while maintaining a sustainable dairy industry was the primary impetus for the project.

Three nearby dairy farms pump approximately 90,000 gallons of manure per day underground to the facility. There is also a manure receiving building that allows for frozen and un-pumpable manure to be delivered to the site. Additionally, approximately 8,000 gallons per day of grease trap or other high energy food waste is added to boost gas production.[38] The complete-mix, mesophilic digester produces enough biogas to generate two MW of electricity, enough to power approximately 2,500 homes for one year. Clear Horizons sells this electricity to the electric company.

The community digester utilizes solids separation for additional nutrient reduction. The Centrisys centrifuge separation technique results in 60-70 percent phosphorus removal from the digestate.[39] Some of the phosphorous-containing solids are used on the farms as animal bedding and to comply with nutrient management plans. However, most of the solids are transported for sale outside of the watershed in an effort to reduce phosphorus loading and improve local water quality. Clear Horizons sells the solids to a wholesaler, who produces EnerGro Fiber, potting mixes containing the sanitized organic nutrients removed from the digestate.

The $12 million project has received a combination of private and public funding: $3.3 million Wisconsin state grant received by Dane County, $2.5 million Federal investment tax credit, and over $6 million in private debt financing.[40] The state funding was dedicated to the phosphorous reduction equipment. A second $3.3 million state grant is going toward the construction of a second community digester under development in Dane County.

The participating farms see benefits in waste management and reduced-cost bedding, without additional work to manage and operate the digester. Clear Horizons benefits from the source of digester feedstock, and sale of electricity, bedding, and potting mix.

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[38] Sullivan, Dan. *County Clusters Farms for Renewable Power Project.* BioCycle February 2012, Vol. 53, No. 2, p. 31
[39] Ibid
[40] Sullivan, Dan. *County Clusters Farms for Renewable Power Project.* BioCycle February 2012, Vol. 53, No. 2, p. 31; http://www.farmfoundation.org/webcontent/Renewable-Energy-Education-Field-Days-Anaerobic-Digester-Webinars-1752.aspx?z=85&a=1752; and http://www.farmfoundation.org/news/articlefiles/1752-David%20Merritt.pdf

For more information, see:

- http://www.fppcinc.org/pdf/2011-march-summit-chris-voell.pdf
- http://www.epa.gov/agstar/documents/conf10/Welch.pdf
- http://www.countyofdane.com/press/details.aspx?id=2465
- http://www.farmfoundation.org/news/articlefiles/1752-David%20Merritt.pdf
- http://www.farmfoundation.org/webcontent/Renewable-Energy-Education-Field-Days-Anaerobic-Digester-Webinars-1752.aspx?z=85&a=1752

Joint Benefits for Public and Private Sectors: Gloversville-Johnstown Joint Wastewater Treatment Facility

The cities of Gloversville and Johnston, NY were previously centers for leather tanning and glove making operations. The joint wastewater treatment facility (WWTF) was sized to handle capacity based on the height of operations for these industries, and upgrades to the WWTF in the 1990s included a two-stage anaerobic digester system. However, industry in the area declined shortly after the expansion, and the plant was left with rising energy costs and excess capacity.

The rise in popularity of Greek yogurt has proved to be a boon for the state's dairy industry. The excess digester capacity at the WWTF has proved to be a boon for the WWTF and the surrounding communities by attracting Fage, a Greek yogurt manufacturer, to an industrial park adjacent to the WWTF. The ability of the WWTF to handle and treat the large amounts of high-strength waste produced in the yogurt making process was key to the yogurt plant's decision to locate in the area. Subsequently, a direct forcemain running between Fage and a 200,000 whey equalization tank at the WWTF has been installed. Whey is fed directly to the WWTF digester system from the tank.

Photo III: Courtesy of ARCADIS

The WWTF'S existing digester system was upgraded in 2009 to improve biogas production efficiency and expand the plant's capacity for on-site electric power generation via a combined heat and power (CHP) system (two 350-kW engine generators). The CHP system now produces enough power to meet 91 percent of the plant's power needs. Because the plant is ineligible to participate in net metering in New York, the WWTF had to size the CHP system such that power cannot be exported to the utility grid. However, the WWTF receives incentives for electricity generated by the CHP system through the New York State Renewable Portfolio Standard, which is administered by the New York State Energy and Research Development Authority. These incentives and the cost savings associated with producing 91 percent of its own power has allowed the plant to invest in further upgrades to the facility and cover rising operation costs.

For more information, see:

- http://www.biocycle.net/2011/05/municipal-and-industry-synergies-boost-biogas-production/
- http://www.asertti.org/wastewater/NY/Gloversville-Johnstown_Fact_Sheet.pdf
- http://www.asertti.org/wastewater/NY/Gloversville-Johnstown_Case_Study.pdf
- http://chp.nyserda.org/facilities/details.cfm?facility=171

Appendix – Acronym List

AD........agricultural digester
ADF........aircraft de-icing fluid
CAUV........current agricultural use value
CFR........code of federal regulation
CHP........combined heat and power
CNG........compressed natural gas
EPA........U.S. Environmental Protection Agency
FOG........fat oil grease
GHG........greenhouse gas
KW........kilowatt
LNG........liquefied natural gas
MGD........million gallons per day
MW........megawatt
NIMBY........not in my backyard
NPDES........national pollution discharge elimination system
PM........particulate matter
REC........renewable energy certificate
RIN........renewable identification number
RPS........renewable portfolio standard
TPY........tons per year
USDA........U.S. Department of Agriculture
WWTF........wastewater treatment facility
WWTP........wastewater treatment plant

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