MassDEP Fact Sheet

Biogas Production

Introduction

The use of sludge from wastewater treatment operations to generate energy is common throughout the United States. Subjecting sludge to anaerobic bacteria in a closed vessel (digester) produces a biogas consisting of approximately 60% methane and 40% carbon dioxide. Biogas from wastewater treatment plants (WWTPs) has been successfully used to provide both heat and electricity. Wastewater treatment plants that don't anaerobically treat sludge on site must transport their dewatered wastewater sludge to a facility for incineration or composting. There are significant energy costs associated with transporting and incinerating wastewater sludge offsite. In 2008, the Water Environment Research Foundation estimated wastewater treatment plants consumed approximately 21 billion kilowatt hours per year. Up to 30% of the financial cost of operating a WWTP was attributed to handling WWTP solids. Historically, the main incentive for using digesters to treat wastewater sludge was to reduce the volume of sludge, thereby reducing the cost of transporting and treating the sludge. The recognition that the methane produced by the digesters could be a significant source of useful energy is more recent. According to a study referenced in the EPA publication "The Benefits of Anaerobic Digestion of Food Waste at Waste Water Treatment Facilities", there has also been movement towards adding post-consumer food waste to anaerobic digesters already in place at wastewater treatment facilities. Food waste has up to three times as much energy potential as biosolids. Commercial and industrial food wastes are seen as ideal for anaerobic digestion due to the high volume produced and the ability to get a clean, homogenous waste stream.

Anaerobic Sludge Digestion in Massachusetts

Currently only five of the 133 WWTPs in Massachusetts use anaerobic digestion in treating wastewater sludge. These include Boston (MWRA/Deer Island WWTP), Greater Lawrence Sanitary District, Clinton WWTP, Pittsfield WWTP, and the Rockland WWTP. With the exception of the Greater Lawrence Sanitary District, which installed digester tanks 7 years ago, the digesters used at the other Massachusetts WWTPs are approximately 20 years old[1]. The primary and secondary digesters at the Pittsfield WWTP, originally built in 1963, were rehabilitated in 2004 and 1997 respectively.

More recently, with funding assistance from the Massachusetts Green Infrastructure SRF program, the Fairhaven Water Pollution Control Facility is undertaking a new biogas to energy project - adding an anaerobic digestion system with combined heat and power capability to its activated sludge facility. This new Combined Heat and Power (CHP) system is expected to provide approximately 149 kW of on-site electric power and heat recovery to the treatment plant. The estimated total cost of this system is $7.6 million, which is anticipated to save approximately $300,000 per year in energy and sludge disposal costs.

At each of the plants, the methane produced during the digestion process is used to keep the digesters heated at the appropriate temperature. Four of the five Massachusetts facilities that use digesters currently flare excess methane, particularly during the summer months. The Boston-Deer Island facility, operated by the MWRA, does not flare methane and has a co-generation system where excess methane is used to heat buildings and generate electricity via steam turbine generators. This saves the MWRA approximately $15 million dollars annually in fuel oil costs. In addition, MWRA's methane generated electricity for the New England grid qualifies as "green" under the Renewable Portfolio Standard program administered by DOER, and therefore results in renewable energy credits (RECs) for MWRA. Other electricity suppliers that do not generate sufficient RECs to meet their obligations under this program can purchase

[1] Funding for the Pittsfield WWTP and the Boston-Deer Island WWTPs co-generation initiatives was a combination of renewable energy grants from the Massachusetts Technology Center (MTC), capacity payments through the Independent Systems Operator of New England (ISO -NE) Load Response Program, and the Massachusetts State Revolving Fund Program. Assistance also was provided by the Northeast Combined Heat and Power (CHP) Application Center and the utility companies.

certificates for other generators. MWRA's Deer Island Plant is the only currently qualified anaerobic digestion facility participating in this program, and in fiscal year 2008 received $1 million from selling its RECs. DOER's website has information on annual RPS reports and requirements. MWRA's website also provides information on its anaerobic digesters.

The Pittsfield WWTP, which generates 80,000 cubic ft of methane per day, recently obtained funding for a co-generation system that will use three turbines to convert excess methane into electricity. Both the Clinton and Rockland WWTPs had previously considered installing a co-generation system but the cost/benefit analysis conducted at the time did not support co-generation. The Rockland WWTP, which has a wastewater flow of 2.5 MGD does not have adequate space for additional digesters.

The Greater Lawrence Sanitary District, with a flow capacity of 52 MGD and an actual flow of +/- 30 MGD, generates approximately 110,103,700 cubic feet of methane annually from its three anaerobic digester tanks. Although it presently does not have a co-generation system and flares roughly 18% of its methane during summer months, GLSD facility uses digester gas to heat digesters and dry its dewatered sludge. This process is the largest consumer of the digester gas produced in the anaerobic digesters. The GLSD sludge drying facility, operational since 2002, handles 38 dry tons per day and produces a dried pellet product that is can be used either as an additive in fertilizer or for direct land application.

Wastewater Biogas Facilities in Massachusetts

Facility	Actual Flow	Use of biogas	Age	Savings
Boston/MWRA	360 MGD	Heat to maintain digester temperatures & generating electricity with steam turbine	~ 20 yrs	$15 mil in saved fuel costs from biogas and CHP (modifications are planned to save $500,000 more); $1 mil in revenue from FY 2008 from Renewable Energy Certificate sales[2]
Pittsfield	13 MGD (2008)	Heat to maintain digester temps.	Flare excess originally built in 1963; later rehab	
Rockland	2.5 MGD	Heat to maintain digester temps .Flare excess	~ 20 yrs	
Greater Lawrence Sanitary District	30 MGD	Heat to maintain digester temps. Flare excess	Tanks installed ~ 2002	Cost savings through sludge treatment/digestion $600,000 /year

[2] http://www.mwra.com/03sewer/html/renewableenergydi.htm

Facility	Actual Flow	Use of biogas	Age	Savings
Clinton	2-4 MGD	Heat to maintain digester temps. Flare excess	~ 20 yrs	
Fairhaven Water Pollution Control Facility	2.7 MGD	Heat recovery for digesting operation & electric power generation	New installation (2010-2011)	Anticipated energy cost & sludge disposal savings of approximately $300,000/year

Technical Challenges of Producing and Using Biogas
Successfully capturing and using biogas as a fuel source from wastewater sludge has been described as an art as much as a science. Maintaining the bacteria population in the digesters that is needed to breakdown wastewater solids is challenging due to the sensitivity of the bacteria to a number of factors, especially temperature and alkalinity. Variability in the type of sludge, amount of sludge, moisture content, temperature, and other factors can cause a massive die-off of the bacteria and subsequent cessation of methane production. In such cases, the resulting gas emissions will frequently consist of carbon dioxide and odorous hydrogen sulfide. Operator skill and detailed knowledge of the plant are critical factors in successful operations.

Types of Electric Generators
The three main technologies used to produce electricity from biogas are microturbines, fuel cells, and internal combustion engines. The appropriate technology is largely determined by the size of the wastewater treatment plant. Microturbine technology is usually more appropriate for WWTPs treating small volumes of flow (minimum flow usually < 6.8 MGD). Minimum flow required for fuel cells and internal combustion technologies are 10.7 MGD and 41.4 MGD respectively. In 2007 EPA estimated the typical costs of installing a CHP system using a 126 kW microturbine was $564,953, with a cost per kW of $4,484. Installing a CHP system using 300 kW fuel cells costs approximately $2,227,890 (approximately $7,426 per kW). A CHP system using a 1060 kW internal combustion engine costs approximately $2,161,425 with a cost per kW of $2,039. These cost estimates do not include the expense of purchasing, installing, and operating the sludge digesters.[3]

Obstacles to Increasing Production and Use of Biogas
Equipping WWTPs with anaerobic digesters to produce biogas may not be feasible in some cases, as the feasibility of such is dependent on the availability of space, the waste water flow, chemical composition of the methane gas, methane production rate, and other considerations. For example, in addition to significant start-up costs, the Rockland WWTP did not have the physical space needed to install or expand additional digesters. Until recently, the flow levels considered conducive for anaerobic digesters and the use of combined heat and power systems was greater than 5 million gallons a day (MGD),**Error! Bookmark not defined.** although facilities with flows > 10 MGD had greater potential.

The equipment and installation cost associated with pretreating raw biogas for use in microturbines is expensive, and may be a major obstacle inhibiting the use of biogas at some WWTP facilities. Pretreatment is needed to remove moisture, hydrogen and siloxanes prior to being as a fuel in microturbines. At the MWRA wastewater treatment facility at Clinton, the cost of the 70-kW microturbine was only $70,000. However, the biogas pretreatment system cost another $330,000. Adding in labor, materials, engineering, and contingencies, the project was estimated at $1.6 million ($23,000/ installed kW). As a result of this high start-up cost, the MWRA elected to stay with their current system, which involved burning biogas in a boiler and using the resulting steam for heat.

[3] Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities. U.S. Environmental Protection Agency, Combined Heat and Power Partnership. April 2007.

Influent flow may not be as much of a limitation as once thought. This has been demonstrated at the Village of Essex Junction WWTP in northwestern Vermont.[4] Although the Essex Junction WWTP handles only 2.0 MGD of flow, sufficient methane is extracted from the sludge to generate 412,000 kWh/yr of electricity. This has reduced electrical costs by $37,000 per year. These results could be encouraging for WWTPs in Massachusetts where approximately 46 % of the WWTPs have a design flow of greater than 2 MGD.

Incentives / Benefits of Increasing Production and Use of Biogas

The benefits of using biogas at WWTPs to produce energy are numerous. In addition to the cost savings associated with the transport and disposal of wastewater sludge, energy from biogas (as oppose to electricity from the grid), can provide heat and power for use in the general operation of a WWTP. The environmental benefits of using biogas are also significant. Anaerobically treating wastewater sludge can significantly reduce the amount of methane (a powerful greenhouse gas) and other greenhouse gases that would otherwise be released to the atmosphere. Digester gas-derived electricity generated by steam turbines and/or other processes and supplied to the New England grid also qualifies as a renewable (green) source of energy under the Massachusetts Renewable Portfolio Standards (RPS) Program.

[4] "Turning Methane into Money: Cost-Effective Methane Co-Generation Using Microturbines at a Small Waste Water Plant", Gillian Eaton, Vermont Energy Investment Corporation; James J. Lutras, Village of Essex Junction, Vermont