Market Characterization Report

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Anaerobic Digester Gas-to-Electricity for the Municipal Wastewater Sector in New York

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Albany, NY
www.nyserda.org

Kathleen O'Connor
Project Manager

Prepared by:
Malcolm Pirnie, Inc.
Latham, NY

NYSERDA
New York State Energy Research and Development Author-

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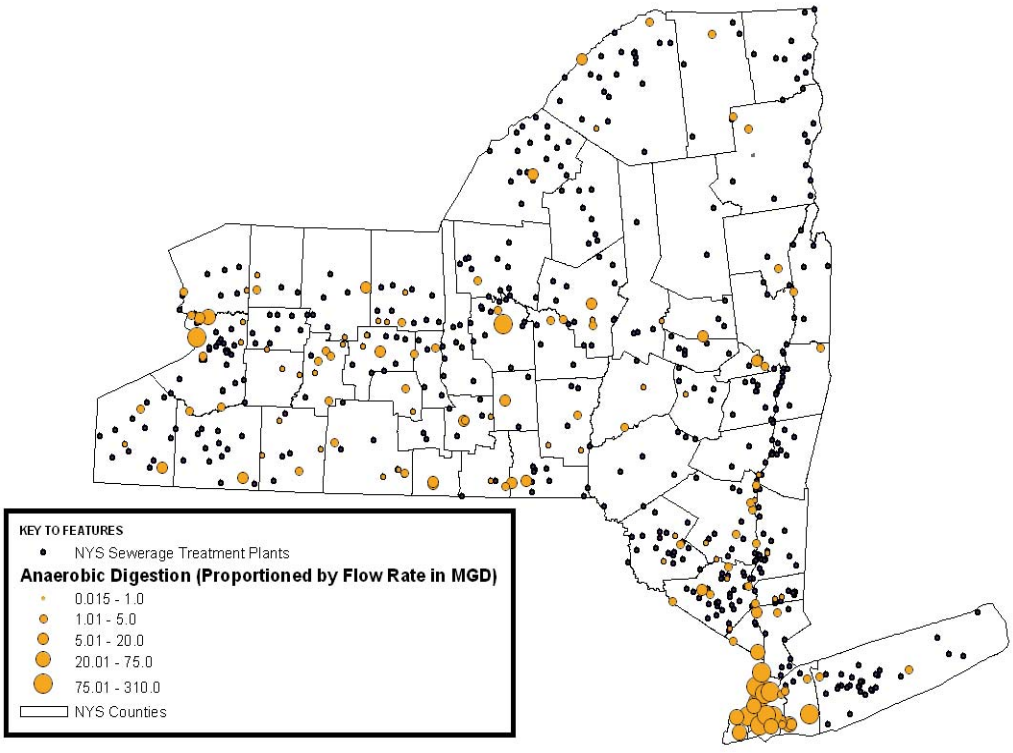
1.1 Description of New York's Wastewater Sector

Based on the New York State Department of Environmental Conservation's Descriptive Data of Municipal Wastewater Treatment Plants in New York State (Descriptive Data), there are 610 permitted municipal wastewater discharges in New York. Of those, 20 permitted discharges in the database are combined sewer overflows or sanitary sewer overflows, leaving a total of 590 municipal wastewater treatment plants (WWTPs). The combined design flow of the 590 WWTPs is approximately 3.7 billion gallons per day (BGD), or roughly 10% of the total national wastewater treatment design capacity reported during a national evaluation conducted by ICF Consulting in 2004 using data provided by the United States Environmental Protection Agency (USEPA). In addition to the 590 municipal WWTPs in New York, there are approximately 95 other non-industrial WWTPs in New York that treat wastewater from camps, schools, and similar properties. The combined capacity of these 95 facilities represents less than 0.2% of the total design capacity in the State. Given the negligible impact on the findings and the municipal focus of this market characterization, these facilities were not included in this evaluation.

Surveys were sent to the 590 municipal WWTPs as part of a Statewide Energy Assessment (conducted under a separate contract). Roughly 20%, 145 of the 590 WWTPs, have anaerobic digestion facilities in place. As part of this Market Characterization, significant follow-up efforts were focused on these 145 WWTPs, as they represent approximately 75% of the overall wastewater treatment capacity within the State.

Figure 1-1 illustrates the geographic distribution of WWTPs in New York and highlights those that currently have anaerobic digestion facilities. The relative size (design capacity) of the WWTPs is indicated by the size of the symbol on the map. It should be noted that several of the WWTPs with anaerobic digestion facilities do not currently operate their digesters, or operate their digesters at reduced rates.

Figure 1-1: Distribution of Wastewater Treatment Plant in NYS



1.2. Estimated Biogas Production and Electrical Production Potential

1.2.1. Estimated Biogas Production

As mentioned previously, significant follow-up efforts were made to maximize the response rate from the 145 WWTPs with existing anaerobic digestion facilities, particularly from the larger facilities that represent the greatest biogas production potential due to the larger organic loads they receive. 67 of these WWTPs responded to the survey. Using the assumptions that 1) 70% of the total solids generated at a facility are volatile solids, 2) a volatile solids destruction rate of 50% is achieved through anaerobic digestion, and 3) 15 cubic feet of biogas is generated for every one pound of volatile solids that is destroyed, the estimated biogas production of the 67 survey respondents is approximately 4.7 billion cubic feet per year (cf/yr).

Extrapolating the data received from the 67 respondents to all 145 WWTPs with existing anaerobic digestion facilities, it is estimated that the biogas production at these 145 WWTPs is 5.2 billion cf/yr. (Note: Over 90% of the estimated biogas production associated with existing digestion facilities is represented by the 67 survey respondents.) Further extrapolating the data received from the 67 respondents, it is estimated that the State's 590 WWTPs have a biogas production potential of 6.7 billion cf/yr (were they all to install anaerobic digestion facilities).

1.2.2. Electrical Production Potential

Based on an average heating value of 550 British thermal units per cubic foot (BTU/cf) of biogas and an electrical conversion efficiency of 25%, the electrical production potential of the 145 WWTPs with existing anaerobic digestion facilities is 24 megawatts (MW). The electrical production potential of the State's 590 WWTPs, if they all were to install digestion and electrical generating facilities, is approximately 31 MW. (Note: the 145 WWTPs with existing digester facilities represent nearly 78% of the State's electrical production potential.)

As distributed electrical generation technologies continue to advance and equipment efficiencies improve, electrical production will increase. Additionally, the overall energy efficiency of biogas-fueled electricity systems can be maximized through recovery of waste heat, which can be used to meet digester heating requirements without sacrificing electrical production potential. Finally, during the summer months, when the electricity demand is typically greatest, facility and digester heating requirements are typically lowest. This would allow biogas-fueled electricity production to be of the greatest benefit as most, if not all, of the biogas produced could be used for electricity generation.

Table 1-1.
Biogas and Electrical Production Potential of NYS WWTPs

Category (Number of WWTPs)	Estimated Biogas Production (cf/year)	Theoretical Heating Value (MMBTU)	Electrical Production Potential [1] (kwh/yr)
Survey Respondents (67)	4,734,000,000	2.59 million	189,000,000
All WWTPs w/Existing Anaerobic Digestion Facilities (145)	5,191,501,000	2.86 million	209,000,000
All WWTPs (590)	6,672,065,000 [2]	3.7 million	268,600,000

[1] Based on an electrical conversion efficiency of 25%.
[2] This represents production potential.

1.3. Existing Biogas Use

At least 40 of the 67 respondents reported that they flare or vent some portion of the biogas produced by their facility. Unfortunately, similar to an assessment recently completed by the USEPA, insufficient data were provided by the respondents to determine the fate of the total volume of biogas produced by these facilities, due in part to the fact that very few facilities have accurate gas metering. However, it is assumed that all WWTPs waste some portion of the biogas that is produced due to limited gas storage and typical fluctuations in gas production. Unless the electrical generating equipment is sized for the maximum rate of biogas production (i.e., maximum biogas flow rate), then biogas in excess of the design throughput of the generating equipment is typically wasted. While WWTPs often have some biogas storage either within the digesters or in separate gas storage facilities, in most instances the storage is insufficient to prevent wasted biogas during periods of peak biogas production. A breakdown of the biogas use as reported by the 67 respondents is shown in Table 1-2.

Table 1-2.
Summary of Biogas Use of Survey Respondents

Biogas Use	Number of Facilities	Theoretical Volume of Gas Produced [1]	Percentage of Total NYS Theoretical Gas Production
Digester Mixing Only	1	2,064,302 cf/yr	0.03 %
Electric Generation Only	3	114,807,935 cf/yr	1.7 %
Facility Heating Only	3	124,695,416 cf/yr	1.9 %
Other Use	4	535,843,537 cf/yr	8.0 %
Flare/Vent Only	9	627,959,856 cf/yr	9.4 %
Combined Electric Generation and Heating	14	1,653,550,694 cf/yr	24.8 %
Digester/Facility Heating	33	1,745,872,035 cf/yr	26.2 %

[1] The value shown is the calculated or reported biogas produced at those survey respondents included in each category. The actual amount of biogas that is recovered and used cannot be determined from the data provided.

1.4. Existing Electrical Generation

1.4.1. Installed Capacity

Seventeen (17) of the 67 respondents reported their installed biogas-fueled generation capacity. The estimated biogas production of these 17 facilities is approximately 1.9 billion cf/yr, or 36% of the estimated biogas production of the 145 WWTPs with existing digestion facilities.

The installed biogas-fueled generation capacity of these 17 facilities, which is used to generate electricity for on-site use or for sale to the commercial grid, is approximately 29 MW. An additional 13 MW of on-site generating capacity is installed at two of the facilities (for a total of 42 MW). While this additional 13 MW of electrical generating equipment has the capability to use biogas as fuel, the equipment was installed knowing that insufficient biogas is available to fire the units, and they are currently operated using natural gas.

Based on the estimated biogas production, the electrical production potential of these 17 facilities is approximately 9 MW. The cause of the discrepancy between installed capacity (29 MW) and electrical production potential (9 MW) is unclear, but is likely due to a number of factors including: the

reporting of redundant equipment or equipment purchased to address potential growth as "installed biogas-fueled generation capacity"; treatment of atypically high strength wastes, hauled wastes, or regional wastes that would result in greater than expected biogas production relative to the estimating methodology used (as described in Section 1.2.1); or the inherent conservativeness of our assumptions.

1.4.2. Electrical Generating and Biogas Clean-up Equipment

The 17 facilities reported having the following biogas-fueled technologies installed: internal combustion engines with generator sets, microturbines, and fuel cells. The reported capacity of these technologies ranges in size from 60 kW to 8,000 kW. The majority of facilities reported having internal combustion engines with a generator set; fuel cells were reported at five WWTPs; and microturbines at one WWTP.

To reduce engine wear and tear and to control emissions, six (6) of the 17 facilities reported having biogas cleanup systems installed in the form of moisture traps and particulate filters. One of these also reported an iron sponge, used for the removal of hydrogen sulfide. Another, the WWTP with the microturbines, reported an activated carbon filter for the removal of siloxanes.

Extrapolating the results from the survey (i.e., approximately 21% of the 145 WWTPs with digesters produce electricity) and applying the electrical production characteristics of the 14 facilities that reported the actual amount of electricity generated (i.e., approximately 45% of their electrical production potential is achieved), it is estimated that approximately 45,000 megawatt-hours per year (MWh/yr) of electricity is currently generated by WWTPs in New York State. [Note: avoided electricity purchases are greater than this, as several WWTPs utilize biogas, rather than electricity, to directly drive pumps and blowers.]

1.5. Assessment of Funding Used for Existing Facilities

Most of the internal combustion engines with a generator set were installed in the late 1980s – early 1990s as part of facility upgrades. More recently, microturbines and fuel cells were installed. Since 2000, NYSERDA has contributed a total of $1 million in funding for fuel cells at four New York City Department of Environmental Protection facilities (26th Ward, Oakwood Beach, Red Hook, Hunts Point). NYSERDA also contributed funding for a fuel cell project at Westchester County's Yonkers Joint WWTP, which went online in 1997, and for a microturbine facility at the Town of Lewiston WWTP. Additionally, NYSERDA funding is pending for projects at the Village of Fredonia WWTP and the City of Schenectady WWTP. Survey respondents reported that New York Power Authority (NYPA), the Clean Water Act revolving loan fund, and a Petroleum Overcharge Restitution fund have also provided funding for existing cogeneration facilities.

The receipt of outside funding does not appear to have directly influenced the performance, efficiency, or capacity of systems that were installed. However, for many projects, particularly those involving the use of fuel cells or microturbines (which offer benefits when compared to traditional internal combustion engines, but are typically more expensive), outside funding was the only reason projects were able to move forward and become successful. With the increased interest in renewable energy, new sources of project funding may be available through carbon credits, renewable energy credits, and Clean Renewable Energy Bonds.

1.6. Installation Costs for Existing Facilities

In many instances, the biogas-fueled cogeneration facilities were constructed as part of a larger project, making identification of the specific costs for the equipment difficult to determine. Based on a very limited number of installations that were able to break out these costs, the average installation cost for the biogas-fueled facilities was $1,700 per kilowatt (kW) of installed capacity, with costs

adjusted to 2007 dollars using the construction cost index published by the Engineering News Record.

Fourteen (14) of the 17 WWTPs reported both their installed generation capacity and the actual amount of biogas-fueled electricity that they generate. The estimated biogas production of these 14 facilities is approximately 1.5 billion cf/yr, or 30% of the estimated biogas production of the 145 WWTPs with existing digestion facilities. These facilities reported a total installed biogas-fueled generation capacity of approximately 28 MW, although, based on their estimated biogas production, their electrical production potential is only 7 MW. These facilities also reported generating a total of 27 million kilowatt-hours per year (kWh/yr) of biogas-fueled electricity. This indicates they are, on average, operating at approximately 45% of their electrical production potential and less than 10% of their installed generation capacity.

1.7. Assessment of Market Potential

Use of anaerobic digester gas offers significant opportunities for the municipal wastewater sector to generate renewable electricity. These opportunities are described in the following sub-sections.

1.7.1. Facilities that Underproduce Electricity Compared to Estimated Biogas Production

Although many WWTPs do employ biogas recovery and use, it appears that many are not capitalizing fully on their electrical production potential based on their estimated biogas production. Based on survey responses, at larger WWTPs (greater than 40 MGD), electrical production is typically limited by the capacity of installed generating equipment (i.e., the generation equipment is undersized compared to the estimated volume of biogas that is produced). Of the 14 WWTPs reporting both their installed generation capacity and the actual amount of biogas-fueled electricity being generated, seven produce between 35 and 75% of their electrical production potential based on their estimated biogas production and three produce less than 20%. Underuse of biogas at these 10 facilities represents an additional 38,000 MWh/yr of electrical generation potential.

1.7.2. Facilities with Excess Generation Capacity Installed

At several WWTPs, installed electrical generating capacity exceeds the estimated biogas production. At three of the 14 WWTPs, the installed capacity is significantly greater than the estimated biogas production. It is estimated that as much as 170,000 MWh/yr of additional biogas-fired electricity could be generated by these three facilities, could biogas production be increased to allow the engines to be operated at full capacity using biogas.

Based on correspondence with WWTP and industry personnel, WWTPs may not be capitalizing on the full potential of their installed biogas-fueled generation capacity for a variety of reasons including labor pressures, unit costs to produce electricity being greater than the unit costs to purchase electricity, operational problems with the electrical generation equipment, air permitting problems, and/or other constraints. Additionally, it may only appear that these facilities are not be capitalizing on their full biogas potential due to the fact that they are actually using some fraction of the biogas for direct firing of boilers to heat the digesters or WWTP buildings or for shaft power. However, as noted earlier, as a result of insufficient data provided by the respondents it is very difficult to determine the exact fate of the total volume of biogas produced by these facilities.

1.7.3. Summary of Opportunities for WWTPs with Existing Digestion Facilities

The greatest near-to-mid term opportunities in the sector are at WWTPs with existing digestion facilities, particularly the 44 with design capacities greater than 4.5 MGD.

For information on other
NYSERDA reports, contact:

New York State Energy Research
and Development Authority
17 Columbia Circle
Albany, New York 12203-6399

toll free: 1 (866) NYSERDA
local: (518) 862-1090
fax: (518) 862-1091

info@nyserda.org
www.nyserda.org

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State of New York
David A Paterson, Governor

New York State Energy Research and Development Authority
Vincent A. DeIorio, Esq., Chairman
Paul D. Tonko, President, and Chief Executive Officer

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Energy Research and
Development Authority