Biogas Utilization: A Regional Snapshot in Understanding Factors that Affect Water Resource Recovery Facilities

A report highlighting WEF Phase II Biogas Data Collection Results

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Biogas Utilization

A Regional Snapshot in Understanding Factors that Affect **Water Resource Recovery Facilities**

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1 Executive Summary

To increase energy self-sufficiency and curb increased costs, many water resource recovery facilities (WRRFs) have embraced energy recovery technologies. The goal of this report is to summarize "sprint" data collection activities, which took place during 2014 as part of a larger collection effort aimed at determining the beneficial use of biogas within the water environment industry. In a continuous effort to update the larger collection of national data compiled in 2013 (see, *Biogas Production and Use at Water Resource Recovery Facilities*), additional smaller, targeted collection efforts with shorter project timeframes (i.e., sprints) focused on filling the data gaps where identified. To that end, this report highlights data compiled for the states in U.S. Environmental Protection Agency (U.S. EPA) region 4, and also provides data from the state of Texas in U.S. EPA region 6 to provide a regional snapshot comparison. Texas was chosen as part of the comparison because a large amount of additional data had been gathered for the state during the past year. As data continues to be supplemented, additional regional reports will be released. The site-specific data can be found at www.biogasdata.org.

The findings highlighted in this report also incorporate secondary data sets that describe economic, financial, environmental, and regulatory conditions, which may provide insights into biogas utilization activities. Previous surveys and reporting note that the most significant obstacle for the beneficial use of biogas continues to be economic (see, *Enabling the Future: Advancing Resource Recovery from Biosolids*). Although there are a variety of factors that drive decision-making, it is worth noting that U.S. EPA's new renewable fuel standard (RFS) ruling should be considered in the overall comparison of factors in future reporting. (See also *Moving Toward Resource Recovery Facilities* [WEF, 2014] for further information regarding drivers of resource recovery, available tools, and guidance on WRRF resource recovery.)

2 Introduction

Today, the concept of "beneficial use" for biosolids has shifted to a community resource too valuable to waste in the context of not only renewable energy needs, but also urban sustainability interests and soil depletion. Resource recovery was a focal point of the 2011 Water Environment Federation (WEF)/National Biosolids Partnership (NBP) report, titled *Charting the Future of Biosolids Management*, which identified both opportunities and challenges for resource recovery in biosolids. In 2013, the report titled *Enabling the Future: Advancing Resource Recovery from Biosolids* built upon the findings of that 2011 effort, further exploring the frameworks, technologies, and outreach needed to fully leverage the resource potential of municipal wastewater solids. Recognizing the economic and environmental value of using biogas as a source of renewable energy and the limits of existing data, WEF with the help of its advisory consensus team and a wide range of volunteers, set out to collect data on (1) existing anaerobic digestion systems at U.S. Water Resource Recovery Facilities (WRRFs) and (2) the current uses of, and potential future opportunities for, using the biogas produced by these facilities. The results are provided in the 2013 report titled *Biogas Production and Use at Water Resource Recovery Facilities*.

To address gaps identified in the dataset after the completion of Phase 1, a focus on innovative approaches to the data collection was employed to ensure effectiveness and efficiency in moving forward. Robust processes and requirements management were applied to enable the continuation of the collaborative commitment to advancing knowledge regarding biogas from biosolids. Phase 2 data collection concentrated on gathering data in regional sprints aimed at focusing on populating data gaps identified during the Phase 1 data analysis, review, and reflections. The sprint teams were assigned states in specific regions of the country (based on U.S. EPA regional designations). Data collection for these regions included the use of questionnaires, face-to-face or telephone interviews, and existing dataset review from a cross-section of available resources. Data from U.S. EPA Regions 4 and 6 have provided a fascinating snapshot of emerging trends that can be obtained from current and developing data collection efforts.

As the portfolio of data is continuously being augmented, WEF engaged in an effort to understand factors that affect the beneficial use of biogas produced from WRRF facility processes. In particular, as the data were gathered, were there noticeable trends specific to small to medium size facilities? To that end, WEF contracted with the American Biogas Council, and Abt Associates for data collection and analysis to assist in this effort. This report presents the Abt Associates methods and findings. Abt Associates provided review of the Region 4 sprint biogas data collected, as well as one state, Texas, in Region 6 to provide additional region-to-region comparison. The group then incorporated existing data sets from secondary sources to provide an economic impact analysis. This report highlights the initial findings and analysis of economic, financial, environmental, and regulatory factors that can affect decisions regarding anaerobic digestion implementation activities at small and medium utilities. This analysis is considered a beginning to a longer ongoing data compilation process to assist the industry in an improved understanding of biogas production and use to conceptualize, design, and develop renewable energy and resource recovery projects.

2.1 Scope

This collaboration between WEF and Abt Associates on biogas data collection is a focused extension of WEF's previous data collection effort, referred to as Phase 1: "*Preparation of Baseline of the Current and Potential Use of Biogas from Anaerobic Digestion at Wastewater Plants*." Phase 1 was an initial effort that is part of a broader, ongoing data compilation process. WEF's goal is that the data gathered, analyses performed, and results reported will provide supporting information to help improve development of programs, technology, and policy to encourage renewable energy production in the United States using biogas from anaerobic digestion. This effort, Phase 2, is the next iteration of data collection.

The scope of this Phase 2 activity includes a review of the existing Phase I database as well as making improvements to the existing database. Improvements include addressing some existing data gaps, and incorporating secondary data sets that describe economic, financial, environmental, and regulatory conditions that may provide insights into biogas utilization activities at small and medium utilities. The primary focus on small and medium utilities stems from the greater uniformity of operation and beneficial use of biogas among large utilities with anaerobic digesters for which information has already been gathered; therefore, gathering additional data to determine biogas use among small to medium size facilities is a target for further study.

This component of Phase 2 focuses on a subset of the national Phase 1 database that includes U.S. EPA Region 4 facilities and facilities in Texas, which is part of EPA Region 6. WEF completed collection of the primary dataset for Region 4 during the summer of 2014, and a similar dataset for WRRFs in all states within U.S. EPA Region 6 in the early fall of 2014.[1]

Ultimately, the cumulative efforts of WEF's data gathering activities are aimed at better understanding important questions, such as the following:

1. What factors explain why some utilities do not operate existing anaerobic digesters?
2. What factors explain why some utilities do not beneficially use biogas from anaerobic digesters?
3. What beneficial uses of biogas are typical among small and medium systems and what factors explain these uses? and
4. How do state regulatory programs affect the operation of anaerobic digesters and beneficial use of biogas?

As described in Section 4, initial findings from the analysis indicate that there may be explanatory information present in key secondary factors, in particular, natural gas prices, landfill tipping fees, bond ratings, and the presence of regulatory incentives for renewable energy investments. Comparisons of these factors among those facilities that do and do not use biogas are generally consistent with intuitive expectations. The NBP will continue to provide additional

[1] U.S. EPA Region 4 includes Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee, and U.S. EPA Region 6 includes Arkansas, Louisiana, New Mexico, Oklahoma, and Texas.

regional and state-specific data as further efforts progress. Additionally, the regional reporting will factor in renewable identification numbers (RINs) generation.

2.2 Background

Wastewater treatment biogas is produced through the breakdown of biodegradable organic matter into a methane-rich gas (biogas) during the anaerobic digestion of domestic/industrial wastewater sludge. The biogas is composed primarily of methane (60 to 70%) and carbon dioxide (30 to 40%), with small concentrations of other constituents. The methane portion of the biogas is a valuable fuel and can be used for many energy needs. Historically, anaerobic digestion has been used to stabilize biosolids at a relatively low cost, and in many cases, the biogas byproduct has been flared rather than being leveraged for use as an energy resource. More recently, utilities across the country are increasingly finding ways to beneficially use the biogas byproduct of anaerobic digestion. Biogas is predominately used on-site, where it is collected, conditioned or processed in some instances, and used for digester heating, building heating, power generation, or driving process machinery. Although many WRRFs are using biogas, the potential still exists to use more based on technical and economic benefits. There is need for a clear and accurate baseline of the current and potential production and use of WRRF biogas, especially for policymakers and legislators. If baseline production and utilization values are inaccurate, there is a tendency to under- or overestimate both biogas utilization and potential.

Recognizing the economic and environmental value of using biogas as a source of renewable energy and the limits of existing data, in June 2011, WEF identified an information gap and sought to fill that gap by assessing the current and potential utilization of biogas from WRRFs in the United States for energy production. WEF established a diverse project team, comprised of nonprofit organizations, communications outlets, consulting engineers, and vendors to assist with this project. With the help of the Project Steering Committee and Advisory Team convened by WEF, the team defined what data would be collected in the initial data collection effort, "Phase 1." Approximately 20 wastewater industry experts were involved in compiling these Phase 1 data. The interactive online database (www.biogasdata.org) presents the data. The database illuminates (1) existing anaerobic digestion systems at WRRFs and (2) current uses of, and potential future opportunities for, using the biogas produced by these facilities.

Building on Phase 1, WEF initiated Phase 2 in the spring of 2014.

2.3 Organization

In this report, Abt Associates describes the data sources and methodologies that were used to incorporate secondary data sets that describe economic, financial, environmental, and regulatory conditions that may provide insights into biogas utilization activities at small and medium utilities. Abt Associates also summarizes the results, and provides insights to limitations, uncertainties, and areas for further research.

- Section 3 provides a description of the methodology, including review of existing data, identification of relevant variables, and data sources.
- Section 4 describes an analysis of the economic, demographic, and regulatory variables.
- Section 5 provides a summary and conclusions.

3 Method

This section describes the method for this effort, which includes three main steps:

1. Review and assess the existing database of WRRFs (Section 3.1);
2. Identify important factors that can affect decisions regarding biogas utilization that are also suitable for secondary data collection (Section 3.2); and,
3. Collect secondary data and incorporate these into the WRRF database (Section 3.3).

3.1 Assess WRRF Database

Abt Associates reviewed the Region 4 and Region 6 (Texas) WRRF data collected to date by WEF. The purpose of the review was to verify the completeness and accuracy of the database, and address any data gaps (missing/questionable values) to the extent feasible. Following the review, Abt Associates selected the data subset to use for the analysis. These data include facility identifiers and location information as well as data fields that are relevant to the study questions. Exhibit 1 describes the subset of key data fields that are the focus for this effort.

Exhibit 1. Survey Data Used in the Analysis

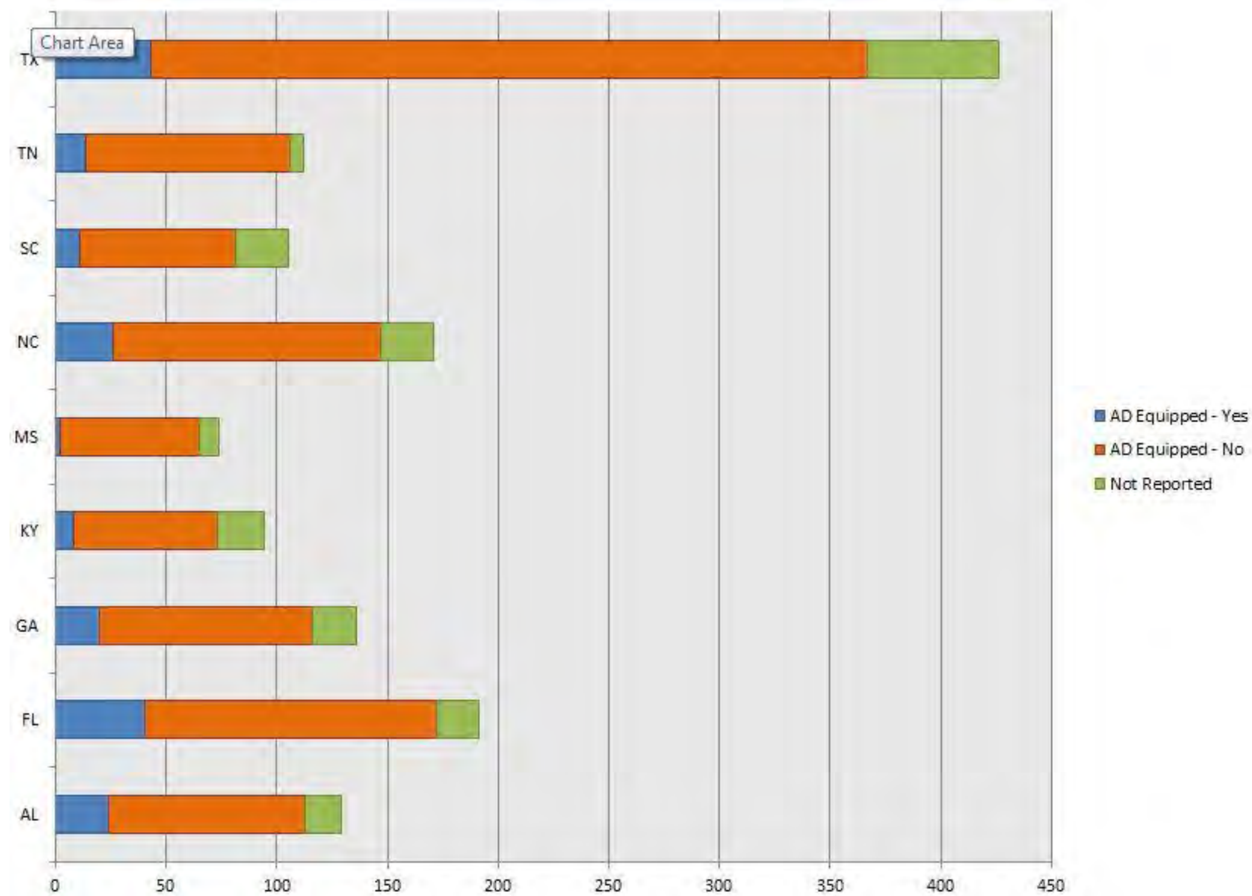
Description
Facility name
State location (abbreviation) of facility
County location of facility
Facility identification number for the National Pollutant Discharge Elimination System (NPDES)
Average flow of wastewater treated by the facility in million gallons per day (MGD)
Yes/No- Facility has anaerobic digesters (AD)
Yes/No- Facility utilizes biogas from anaerobic digesters
Yes/No - Biogas is used to drive machinery
Yes/No - Biogas is used to heat digesters
Yes/No - Biogas is used by heating, ventilation, and air conditioning (HVAC)
Yes/No - Biogas is injected into pipeline
Yes/No - Biogas is used to generate electricity using combustion engine
Yes/No - Biogas is used to generate electricity using turbine
Yes/No - Biogas is used to generate electricity using microturbine
Yes/No - Biogas is used to generate electricity using fuel cell

The database contains survey results from 1,012 WRRFs across the eight states of Region 4 and 426 in Texas (Exhibit 2). Information included in the database includes facility location, flow rates, use of anaerobic digesters, biogas utilization, as well as information on sludge and biosolids use. Other information in the database includes facility specific comments and contact information gathered while conducting follow-up research.

Exhibit 2. Number of WRRFs Equipped with Anaerobic Digesters by State

State	Yes	No	Not Reported	Total
AL	24	89	16	129
FL[1]	40	132	19	191
GA	20	96	20	136
KY	8	65	21	94
MS	2	63	9	74
NC	26	121	24	171
SC	11	70	24	105
TN	14	92	6	112
Region 4 Subtotal	*145*	*728*	*139*	*1012*
TX	43	324	59	426
Total	**188**	**1052**	**198**	**1438**

1. Includes a number of facilities that may not have anaerobic digesters on-site, but ship sludge to a regional anaerobic digester facility.



Of the 1,012 Region 4 facilities in the database, 145 (14% of Region 4 facilities) are equipped with anaerobic digesters, whereas the majority (72%) do not have anaerobic digesters. The pattern is similar in Texas where the respective percentages are 10% and 76% of WRRFs. By comparison, the national Phase I database indicates that relatively more facilities (24%) have anaerobic digesters (1,238 of the 5,127 WRRFs surveyed during Phase 1).[2]

Exhibit 3 summarizes the number of facilities using anaerobic digesters by flow size category, since system flow is a key determinant of the feasibility of biogas utilization systems. The EPA's 2007 Combined Heat and Power Partnership (CHPP) report[3] highlighted a challenge for biogas use in smaller systems by showing that influent flow rates of 5 MGD or greater were typically required to produce biogas in quantities sufficient for economically feasible combined heat and power systems.

Exhibit 3. Number of WRRFs Equipped with Anaerobic Digesters, by Flow Category

Flow Size (MGD)	Yes	No	Not Reported	Total
Region 4				
No data	30	479	128	637
Less than 1	8	21	1	30
1 - <5	31	128	4	163
5 - <10	24	60	1	85
10+	52	40	5	97
Total	**145**	**728**	**139**	**1,012**
Texas				
No data	2	90	57	149
Less than 1	3	78	1	82
1 - <5	15	113	0	128
5 - <10	8	27	0	35
10+	15	16	1	32
Total	**43**	**324**	**59**	**426**

At the same time, more recent analyses indicate that use of anaerobic digestion is feasible at facilities with influent flow rates less than 5 MGD if biosolid loadings are high enough, or if co-digestion processes increase biogas generation.[4] Exhibit 4 shows the WRRFs using co-digestion are essentially limited to the largest facilities (10+ MGD), implying that co-digestion is not a requirement for anaerobic digestion feasibility below 5 MGD. A number of additional resources are available that highlight the use of co-digestion as a means for boosting energy and closing cost gaps in decision-making for the beneficial use of biogas.[5]

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2 Water Environment Federation (WEF), July 2013. Biogas Production and Use at Water Resources Recovery Facilities in the United States: Phase I Data Report. Project 11-WSEC-01.

3 U.S. EPA, Combined Heat and Power Partnership (CHPP), 2007. The Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities.

4 U.S. EPA, Combined Heat and Power Partnership (CHPP), October 2011. Opportunities for Combined Heat and Power at Wastewater Treatment Facilities: Market Analysis and Lessons from the Field.

5 Among additional resources on the topic of co-digestion, see "Food Waste to Energy: How Six Water Resource Recovery Facilities are Boosting Biogas Production and the Bottom Line," U.S. EPA, 2014; and

Exhibit 4. Number of WRRFs with Co-Digestion

Flow Size (MGD)	WRRFs Operating Anaerobic Digesters Utilizing Co-Digestion
Region 4	
No data	2
Less than 1	0
1 - <5	2
5 - <10	1
10+	11
Total	**16**
Texas	
No data	0
Less than 1	0
1 - <5	0
5 - <10	0
10+	3
Total	**3**

This study focuses on the utilization of biogas among the subset of facilities that have anaerobic digesters (145 in Region 4 and 43 in Texas). Exhibit 5 shows that 82 Region 4 WRRFs (56%) indicate that they beneficially use the biogas by-product, 20 (14%) do not use biogas, and information is not available for 43 (30%). Facilities in Texas are more evenly divided, with 44% using biogas and 46% not using biogas (only 10% do not report use). In both cases, this utilization rate is substantially lower than the Phase I overall national data, which indicates that 85% of systems with anaerobic digesters also beneficially use the biogas by-product. However, the true distribution within Region 4 is uncertain because 30% of the sample is not reported with respect to biogas use.

Exhibit 5. Number of WRRFs Beneficially Using Biogas by State

State	Utilized	Not Utilized	Not Reported	Total
AL	13	4	7	24
FL	20	2	18	40
GA	14	4	2	20
KY	3	0	5	8
MS	0	2	0	2
NC	16	2	8	26
SC	5	4	2	11
TN	11	2	1	14
Region 4 Subtotal	*82*	*20*	*43*	*145*

"Co-Digestion of Organic Waste Products with Wastewater Solids and economic Model (OWSO5R07), Water Environment Research Foundation, 2014.

State	Utilized	Not Utilized	Not Reported	Total
TX	19	20	4	43
Total	**101**	**40**	**47**	**188**

Exhibit 6 shows the number of facilities with anaerobic digesters that beneficially use the biogas by-product by facility flow size category. The Region 4 data show that, for the WRRFs for which both anaerobic digesters and flow information is available, small and medium facilities (>1 to 5 MGD) are less likely to beneficially use the biogas (19/30 = 63%) compared to larger facilities (58/65 = 89%), but there is nevertheless a substantial portion of small and medium facilities using biogas. By contrast, beneficial biogas use in Texas is dominated by larger facilities (84% of facilities using biogas are greater than 5 MGD). Only 3 out of all small and medium Texas WRRFs (3/16, or 19%) with reported anaerobic digesters and flow data indicated that they beneficially use the biogas.

The Phase I national database indicates that about 75% of small/medium facilities (<5 MGD) with anaerobic digesters also use the biogas, whereas the fraction using biogas is more than 90% for facilities with flow greater than 5 MGD. These overall national values are fairly consistent with the Region 4 data, and inconsistent with the Texas data.

Exhibit 6. Number of WRRFs Beneficially Using Biogas by Average Flow

Flow Size (MGD)	Yes	No	Not Reported[1]	Total
Region 4				
Not Reported	5	2	21	28
Less than 1	1	0	7	8
1 - <5	18	11	4	33
5 - <10	17	3	4	24
10+	41	4	7	52
Total	**82**	**20**	**43**	**145**
Texas				
Not Reported	0	0	2	2
Less than 1	1	1	0	3
1 - <5	2	12	1	15
5 - <10	2	6	1	8
10+	14	1	0	15
Total	**19**	**20**	**4**	**43**

1. Twelve of these Region 4 facilities are in Florida and, as part of the JEA (formerly the Jacksonville Electric Authority), transport sludge to a regional facility that has anaerobic digesters and utilizes biogas (five in the smallest size category, four in the next size category, two in the third, and one in the largest category). Although the Region 4 database includes these facilities among those having anaerobic digesters, removing them may improve data quality.

WRRFs use the biogas byproduct of anaerobic digesters for a variety of purposes, categorized below in Exhibit 7. Some facilities use biogas in more than one way, resulting in a total number of uses that exceeds the number of facilities. For example, in Region 4, 82 facilities reported using biogas and 31 of those facilities use biogas in more than one way, ultimately resulting in 135 distinct instances of use in Region 4.[6]

Historically, and presently, WRRFs use biogas predominantly for process heating with boilers that maintain the mesophilic and thermophilic temperatures required for anaerobic digestion (56% and 50% of facilities in Region 4 and Texas, respectively). Other uses include supporting HVAC systems and driving facility machinery.

Only four facilities indicated use of pipeline injection. The different composition and the lower energy content of biogas as compared to natural gas complicate storage and transportation when the biogas is not used on-site. The costly treatment and upgrading processes required before it can be injected into existing pipeline infrastructure generally limit this use to the largest facilities. Although, EPA's RFS ruling is expected to help overcome this limitation.

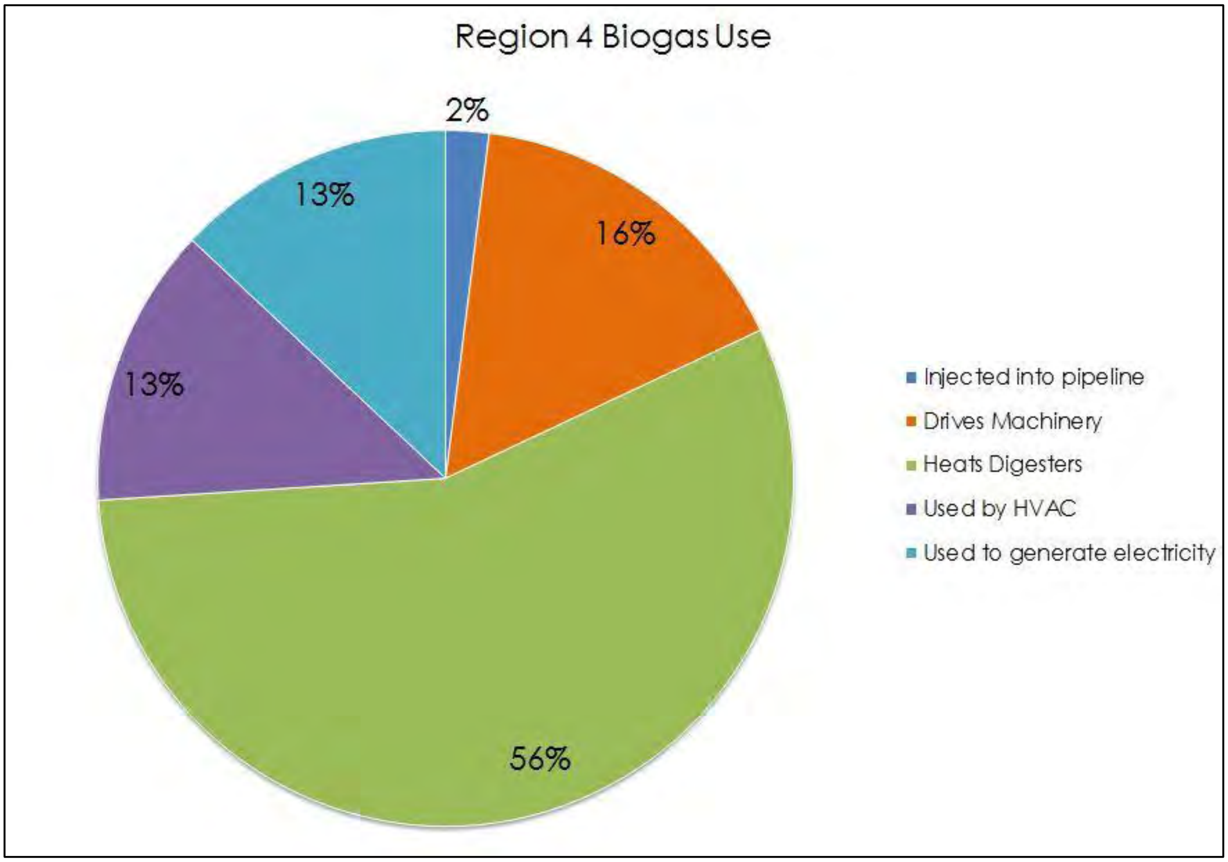

Exhibit 7. Beneficial Use of Biogas at WRRFs

Biogas Use	Number (percent of beneficial use)
Region 4	
Injected into pipeline	3 (2%)
Drives machinery	21 (16%)
Heats digesters	76 (56%)

6 Five Texas facilities indicated multiple uses of the biogas.

Biogas Use	Number (percent of beneficial use)
Used by HVAC	17 (13%)
Used to generate electricity	18 (13%)
Total Number of Distinct Uses	**135 (100%)**
Texas	
Injected into pipeline	1 (3%)
Drives machinery	4 (12%)
Heats digesters	17 (50%)
Used by HVAC	3 (9%)
Used to generate electricity	9 (26%)
Total Number of Distinct Uses	**34 (100%)**

Exhibit 8 shows uses by flow category, for the WRRFs that provided flow data. Based on the available data, there is also substantially less use of biogas to generate electricity at small/medium WRRFs.

This pattern is generally consistent with the Phase I national database, which showed 48% use biogas for digester heating, 27% for building heating, 16% for power generation, 8% for driving process machinery, and 1% for pipeline injection.

Exhibit 8. Beneficial Use of Biogas at WRRFs by Flow Category[1]

Biogas Use	Number (%)
Region 4	
Less than 1 MGD	
Heats digesters	1 (100%)
1 - <5 MGD	
Injected into pipeline	1 (4%)
Drives machinery	2 (7%)
Heats digesters	18 (64%)
Used by HVAC	5 (18%)
Used to generate electricity	2 (7%)
Total 1 - <5 MGD	28 (100%)
5 - <10 MGD	
Drives machinery	4 (15%)
Heats digesters	16 (62%)
Used by HVAC	4 (15%)
Used to generate electricity	2 (8%)
Total 5 - <10 MGD	26 (100%)
10+ MGD	
Injected into pipeline	2 (3%)
Drives machinery	10 (14%)
Heats digesters	38 (54%)
Used by HVAC	7 (10%)
Used to generate electricity	13 (19%)
Total 10+ MGD	70 (100%)

Exhibit 8. Beneficial Use of Biogas at WRRFs by Flow Category[1]

Biogas Use	Number (%)
Texas	
Less than 1 MGD	
Heats digesters	1 (100%)
1 - <5 MGD	
Heats digesters	2 (100%)
5 - <10 MGD	
Heats digesters	2 (66%)
Used to generate electricity	1 (33%)
Total 5 - <10 MGD	3 (100%)
10+ MGD	
Injected into pipeline	1 (4%)
Drives machinery	4 (14%)
Heats digesters	12 (43%)
Used by HVAC	3 (11%)
Used to generate electricity	8 (29%)
Total 10+ MGD	28 (100%)
1. 31 Facilities in Region 4 indicated multiple biogas use categories, 5 Facilities in Texas indicated multiple biogas use categories	

3.1.1 Address Data Gaps

The survey data does not contain average flow for all facilities. Among the 873 Region 4 facilities that report anaerobic digester status (Exhibit 3), 609 did not report average flow. Abt Associates was able to obtain average daily flow information for 100 of these facilities from EPA's ICIS-NPDES database. Similarly, of the 102 Region 4 facilities with a known biogas utilization status (see Exhibit 6), Abt Associates was able to estimate average flow rates for 6 (leaving 7 with missing flow rates) of these facilities by searching utility, state, and EPA websites for flow rate information; however, as seen in Exhibit 6, flow data gaps remain in Region 4. Average flow is not available for about 25% of Texas facilities that report anaerobic digester status. There are no flow data gaps among Texas facilities with a known biogas utilization status.

In the Texas facility data, Abt Associates changed two biogas utilization responses from "no" to "yes" because the facility indicated a specific biogas use (heats digesters). Additionally, Abt Associates changed two anaerobic digester utilization responses from "yes" to "no" because the facility comments indicated that the anaerobic digester system had been non-operational for a number of years.

3.1.2 Review Comments

For facilities *not* utilizing biogas, Abt Associates reviewed the facility-specific comments to identify any obstacles preventing biogas use. The comments provide limited information, but contain some general reasons for why biogas is not currently being utilized: size limitations, technical limitations, and timing (i.e., upgrades to use biogas are in the planning stage). Exhibit 9 shows the estimated distribution across the facilities not beneficially using biogas. One facility in

Georgia with a design flow of 1 MGD cited size as a limiting factor (average flow data are not available for this facility). Of the limited number of comments, most cited technical limitations as the constraining factor. An example of a technical limitation is poor quality gas production that cannot be used in boilers for digester heating.

Exhibit 9. Summary of Comments[1] for WRRFs not Utilizing Biogas

Reason	# Facilities
Region 4	
Size limitations	5%
Technical limitations	25%
Upgrades planned to use biogas	15%
Texas	
Size limitations	15%
Technical limitations	5%
Upgrades planned to use biogas	10%
1. Based on subjective characterization of the comments received.	

3.2 Identify Important Factors and Data Sources for Secondary Data Collection

WRRFs most frequently use biogas in a boiler to provide digester heating and/or provide space heating for buildings on-site. The biogas can also be used as fuel to generate electricity and heat in a CHP system using a variety of prime movers, such as reciprocating engines, microturbines, or fuel cells. Regardless of the application, these approaches offer multiple potential benefits to the facility and broader community, including:

- Energy cost savings by offsetting electricity or natural gas purchases;
- Financial and other benefits (e.g., public relations) arising from state renewable portfolio standards (RPS) and other state, local, or utility incentive policies/programs;
- Enhance facility resilience to power outages and/or volatility in fuel prices; and,
- Reductions of emissions of greenhouse gases and other air pollutants.

However, the ability to leverage these benefits is likely affected by a myriad of economic, demographic, and regulatory factors beyond the critical elements of system capital and O&M costs. The objective of the secondary data collection effort is to identify important factors that 1) may affect the utilization of biogas, and 2) are observed in secondary data sources that can be integrated with the WRRF database. The variable concepts included in the analysis serve as indicators of the potential for biogas applications at WRRFs, but the specific technical and economic circumstances of each individual WRRF ultimately inform and determine any implementation decisions.

3.2.1 Economic

Biogas produced by anaerobic digesters can be used to offset all or a portion of a WRRF's energy demand when used for digester heating, space heating, and/or electricity generation. The biogas allows the facility to displace electricity and/or natural gas for digester heat loads that they would otherwise have to purchase. As part of an overall feasibility analysis, WRRF's can consider the estimated costs of electricity or fuel production on an equivalent unit basis to their current retail electric rate to evaluate the potential cost savings. Economic indicators of interest include electricity and natural gas prices. All things being equal, one would expect to see more biogas utilization in areas that have relatively high electricity and natural gas prices.

The U.S. Energy Information Administration (EIA)[7] provides 2012 utility-specific data on the revenue (dollars), sales (megawatt-hours), and number of customers in the following categories: commercial, industrial, transportation, and residential. For each county, Abt Associates identified the utilities that operate within the county, and obtained the average industrial revenues and sales for these utilities. To estimate an electricity price, Abt Associates calculated annual revenues per MWh for industrial customers in the county. For natural gas prices, the EIA provides state- and year-specific data on natural gas sold to industrial customers from 1997 to 2012.[8] For each state, Abt Associates used the 10-year average price between 2003 and 2012 in nominal dollars per thousand cubic feet.

In addition to energy prices, a facility may also consider trade-offs present in alternative approaches for handling biosolids, such as landfill disposal. Landfill tipping fees faced by WRRFs are an important factor in that assessment, and are included in the secondary indicator database. Fees at the WRRF level are not readily available. Therefore, Abt Associates used state landfill tipping fee data from Green Power Inc (2014).[9]

Indicators describing the ability to finance the development of a biogas utilization project – whether as a stand-alone project or as part of a larger facility equipment and process upgrade – are also important to include in the database. The financing component of such activities can depend on compatibility with federal, state, and local incentive/regulatory programs (i.e., see 3.2.3 below), as well as the facility's overall financial condition and other financing opportunities that may be available. To capture facilities' overall financial condition and credit worthiness, the secondary database includes current sewer rates and bond ratings.

With respect to financing opportunities, the emerging market for "green bonds" is also likely to have a significant impact on future investments in biogas systems, but is not accounted for in the secondary database. Green bonds is a rapidly growing market that includes primarily investment-grade bonds where the use of proceeds meets qualifying criteria aimed at generated climate or environmental benefits.[10] A range of sectors, including water and wastewater, can benefit from green bond opportunities, in particular with improved "green" criteria standardization and transparency for issuers and investors.[11] For example, Florida's East Central Regional Wastewater Facilities Operation in Palm Beach County, plans to bring the Southeast's first green bond offering to market to fund capital upgrade projects. "The projects will improve the quality of the biosolids, reduce the volume produced, reduce energy

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7 Form EIA-861 Detailed Data File (2012).

8 http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SAL_a.htm

9 http://www.cleanenergyprojects.com/Landfill-Tipping-Fees-in-USA-2013.html

10 Bonds & Climate Change – The State of the Market in 2014, HSBC and Climate Bond Initiative, July 2014, http://www.climatebonds.net/files/files/-CB-HSBC-15July2014-A4-final.pdf

11 For example, see Ceres' recently developed voluntary set of guidelines, *Green Bond Principles*, www.ceres.org/resources/reports/green-bond-principles-2014-voluntary-process-guidelines-for-issuing-green-bonds/view

consumption, and generate renewable gases that can generate energy - all benefits that qualify the securities to be issued as green bonds, according to ECR engineers and officials." [12]

For sewer rates, the U.S. Census Bureau provides state-specific data on government finances (from the 2010 Annual Surveys of State and Local Government Finances), including expenditures on wastewater treatment. For each state, Abt Associates collected the total expenditures on wastewater by all local governments in the state. To calculate per-capita expenditures, Abt Associates collected the total state population from the 2010 1-year American Community Survey (ACS). Abt further adjusted the state population based on the share of the state population on public sewer systems (versus septic or other) from the 1990 Decennial Census, which are the most recent available data for this parameter.[13] As such, this variable represents local government wastewater expenditures per person on public wastewater systems.

Abt Associates used the Electronic Municipal Market Access (EMMA) website[14] to obtain county bond ratings from Standard & Poor. If a county bond rating is not available, Abt Associates used another government entity within the county, such as a Board of Education, and if a Standard & Poor's rating is not available, Abt Associates used an alternative rating (such as Kroll Bond Rating Agency - KBRA).

3.2.2 Demographic

Overall demographic trends in areas served by WRRFs can also influence whether and how a facility uses biogas. As noted previously, system flow is potentially a limiting factor for biogas production. Facilities serving large and/or growing populations can benefit from the additional biosolid streams to increase biogas production. According to Metcalf & Eddy, approximately 1.0 cubic foot of digester gas can be produced by AD per person per day.[15] Recognizing the potential impact of population growth on biogas production, Abt Associates includes population in the county where the facility is located, as well as past population change, including change between 2000 and 2010 and more recent change between 2010 and 2013. Abt Associates used U.S. Census Bureau data for these variables, including the population in 2000 (from Census 2000, Summary File 1, Table DP-1), 2010, and 2013 (both from the Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013). Abt Associates also includes county-level median household income (MHI) from the U.S. Census Bureau 2012 5-year ACS.

3.2.3 Regulatory

Federal, state, local, and utility policies relating to renewable energy production or climate change, and environmental regulations can affect the production of biogas-based energy at WRRFs. In many instances, the regulatory environment supports a variety of programs/incentives to encourage the development of biogas utilization systems by providing subsidies, tax credits, and financing mechanisms for renewable power.

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12 *The Bond Buyer*, October 24, 2014, http://www.bondbuyer.com/news/regionalnews/florida-wastewater-deal-pitched-as-southeasts-first-green-bond-1067317-1.html

13 http://water.epa.gov/infrastructure/wastewater/septic/census_index.cfm

14 http://emma.msrb.org/IssuerHomePage/Map

15 Metcalf & Eddy, "Wastewater Engineering: Treatment and Reuse, 4th Edition," 2003.

In some instances, a facility may be limited – rather than enabled – by the regulatory environment. For example, a facility may be limited in the ability to supplement the biosolid stream with fats, oils, and grease because of existing regulations.[16]

To identify whether each state has financial incentives and regulatory requirements for renewable energy (including biogas), Abt Associates used the Database of State Incentives for Renewables & Efficiency (DSIRE) from the U.S. Department of Energy.[17] For each state, Abt Associates used the information on state, local, utility, and nonprofit financial incentive programs, including: personal tax; corporate tax; sales tax; property tax; rebates; grants; loans; industry support; bonds; and performance-based incentives. For regulations, Abt Associates used the information on state, local, and utility regulations in the following categories: public benefit funds; RPS; net metering; inter-connection; contract license; equipment certification; access law; construction and design standards; green power purchasing; and required green power.

For all incentives and regulations, Abt Associates examined the program information, and eliminated it if it met one or more of the following conditions implying that it is not relevant to biogas:

- Residential projects only,
- Commercial or corporate projects only,
- Specific to non-biogas renewable technologies,
- Farm projects only,
- State office projects only, and
- Leadership in Energy and Environmental Design (LEED) building standards.

Abt Associates also consulted the Policies and Incentives database of U.S. EPA's Combined Heat and Power Partnership (CHPP)[18] to identify additional relevant incentives and regulatory programs in each of the states. This process indicated that some states in the region have loans for renewable energy, performance-based incentives, renewable portfolio standards, net metering, and inter-connection programs. The rest of the financial incentive and regulatory categories were not relevant for WRRF biogas projects. For each facility, Abt Associates entered these variables as a 1 if the facility is located in a state with at least one such incentive/regulatory program, and 0 if Abt Associates did not find such a program in the state (rather than the number of programs, as presented in the DSIRE database).

One such program is AlabamaSAVES, a loan program administered by Abundant Power Solutions, LLC. This program uses funds from private lenders to provide low-interest loans (currently, the interest rate is 0%) for energy efficiency projects undertaken by local governments, school systems, and public universities and colleges in the state. Each loan is between $50,000 and $350,000, and may be used for energy efficiency improvements and retrofits of buildings, water treatment plants, street lights, fleet vehicle conversions, and others.

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16 The database does not capture the presence of these "limiting" kinds of regulations.

17 http://www.dsireusa.org/summarytables/finre.cfm for financial incentives; http://www.dsireusa.org/summarytables/rrpre.cfm for policies and regulations.

18 http://www.epa.gov/chp/policies/database.html

Eligible technologies include biomass and other renewable energy sources in addition to energy efficiency retrofits.[19]

Another financial incentive program is the Tennessee Valley Authority (TVA) Green Power Providers. Under this program, TVA provides $1,000 to new renewable energy generation systems (to offset upfront costs) and purchases 100% of the output at the retail electricity rate for a 20-year contract term. During the first ten years, TVA pays an additional $0.03 per kilowatt-hour above the retail electricity rate. Eligible renewable energy systems include solar, wind, biomass (including from wastewater), and hydro systems with nameplate capacity between 500 watts and 50 kilowatts. This program extends across multiple states including Alabama, Georgia, Mississippi, North Carolina, and Tennessee.[20] Exhibit 10 summarizes the type of policies and programs available in each state that may support investments in biogas utilization systems.

Exhibit 10. Existence of Financial Incentives and Regulatory Programs for Renewable Energy[1]

State	Financial Incentives for Renewable Energy	Regulations Supporting Renewable Energy Production
Region 4		
AL	Loans, performance-based incentives	None
FL	None	Renewable Portfolio Standards
GA	Performance-based incentives	None
KY	Performance-based incentives	Net-Metering, Inter-Connection
MS	Loans, performance-based incentives	None
NC	Loans, performance-based incentives	Renewable Portfolio Standards, Net-Metering, Inter-Connection
SC	Performance-based incentives	Renewable Portfolio Standards, Net-Metering, Inter-Connection
TN	Performance-based incentives	None
Texas		
TX	None	Renewable Portfolio Standards, Net-Metering
Notes: See Appendix A for a description of these program/policy categories 1. State, Local, Utility, Non-Profit incentive sources		

While there are a variety of factors that drive decision making, it is worth noting that EPA's new renewable fuel standard (RFS) ruling should be considered in the overall comparison of factors in future reporting. RFS activity points to the likelihood that WRRFs might consider the treatment and upgrade of biogas to pipeline quality to inject into the grid, and sell as a renewable fuel to earn money from generated RINs. Additional data on RINs generation after July 2014 show an increase in RINs generation after July 2014. Cellulosic RINs/Volume were 4,157 gallons in July

19 For more information, see: Alabama Department of Economic and Community Affairs (ADECA). 2014. Local Government Energy Loan Program. A Public/Private Partnership of the ADECA Energy Division and Power South Development Corporation.

20 Tennessee Valley Authority (TVA). 2014. Green Power Providers: 2014 Green Power Providers Program. http://www.tva.com/greenpowerswitch/providers/

2014, and sharply increased to 3,492,106 gallons in August 2014 (after EPA's ruling) and reached to 8,532,518 gallons in December 2014. With the cellulosic credits coming in after the July ruling, the market is changing rapidly. An estimated 99% of cellulosic RINs have been generated from biogas (since August 2014). (see, http://www.epa.gov/otaq/fuels/rfsdata/2014emts.htm)

3.3 Collect Secondary Data

Based on the aforementioned considerations, Abt Associates collected secondary data from publicly available sources and incorporated these data into the facility database. Relevant data include socio-demographic data (e.g., population and income), economic data (e.g., facility bond rating, gas and electricity prices), and regulatory data (e.g., renewable energy policies and programs). Abt Associates restricted data collection to authoritative resources such as federal, state, and local agency publications and databases. Absent facility-specific information for each data item, Abt Associates relied upon county and state-level values.

Exhibit 11 summarizes the secondary indicators and the sources of these data. For each of the WRRFs included in the analysis, Abt Associates identified the county in which it operates. For some secondary variables, Abt Associates found county-specific data. For other variables, only state-specific data are available.

Exhibit 11. Summary of Secondary Indicators and Data Sources

Variable	Description/Units	Geographic Scope	Source
Economic Variables			
Energy prices	$/MWh for industrial customers (average for utilities in county); 2012$	County	U.S. Energy Information Administration (EIA). 2012. Form EIA-861 Detailed Data File.
Municipal wastewater expenditures per capita	Wastewater expenditures per year by local governments per person using public wastewater services; 2010$	State	Expenditure data from U.S. Census Bureau. 2010. Annual Surveys of State and Local Government Finances. Population data from U.S. Census Bureau. 2010. 1-year American Community Survey (ACS). Share of population on public wastewater services from U.S. Census Bureau. 1990. Decennial Census.
Bond rating	Most recent available Standard & Poor's bond rating for county or government entity within county	County	Electronic Municipal Market Access (EMMA)
Landfill tipping fees	2013$	State	Green Power Inc (2014). Landfill Tipping Fees in USA.

Exhibit 11. Summary of Secondary Indicators and Data Sources

Variable	Description/Units	Geographic Scope	Source
Natural gas prices	10-year average nominal dollars (2003 to 2012) per 1000 cubic feet	State	U.S. Energy Information Administration. Natural Gas Price.
Demographic Variables			
Population	2013 Population for the county where the WRRF is located	County	U.S. Census Bureau. 2013. Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013.
Population change, 2000 to 2010	Change in population in county where the WRRF is located between 2000 and 2010 (expressed as a percent of the 2000 population)	County	2000 population data from U.S. Census Bureau. 2000. Summary File 1, Table DP-1. 2010 population data from U.S. Census Bureau. 2013. Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013.
Population change, 2010 to 2013	Change in population in county where the WRRF is located between 2010 and 2013 (expressed as a percent of the 2010 population)	County	Population data from U.S. Census Bureau. 2013. Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2013.
Median household income (MHI)	2012$	County	U.S. Census Bureau. 2012. 5-year American Community Survey (ACS).
Regulatory Variables			
Loans for renewable energy	1 indicates that the state where the WRRF is located has at least 1 loan program relevant to biogas projects, 0 indicates that it does not	State, Local, Utility	U.S. Department of Energy. 2014. Financial Incentives for Renewable Energy. Adjusted to eliminate programs not relevant to WRRF biogas projects.
Performance based incentives	1 indicates that the state where the WRRF is located has at least 1 performance based incentive program relevant to biogas projects, 0 indicates that it does not	State, Local, Utility	U.S. Department of Energy. 2014. Financial Incentives for Renewable Energy. Adjusted to eliminate programs not relevant to WRRF biogas projects.

Exhibit 11. Summary of Secondary Indicators and Data Sources

Variable	Description/Units	Geographic Scope	Source
Renewables portfolio standards (RPS)	1 indicates that the state where the WRRF is located has at least 1 RPS program relevant to biogas projects, 0 indicates that it does not	State, Local, Utility	U.S. Department of Energy. 2014. Rules, Regulations, & Policies for Renewable Energy. Adjusted to eliminate programs not relevant to WRRF biogas projects.
Net metering	1 indicates that the state where the WRRF is located has at least 1 net metering program relevant to biogas projects, 0 indicates that it does not	State, Local, Utility	U.S. Department of Energy. 2014. Rules, Regulations, & Policies for Renewable Energy. Adjusted to eliminate programs not relevant to WRRF biogas projects.
Inter-connection	1 indicates that the state where the WRRF is located has at least 1 inter-connection program relevant to biogas projects, 0 indicates that it does not	State, Local, Utility	U.S. Department of Energy. 2014. Rules, Regulations, & Policies for Renewable Energy. Adjusted to eliminate programs not relevant to WRRF biogas projects.

4 Analysis of Secondary Data

This section summarizes the results of analysis of the secondary variables described in Section 3.

4.1 Economic Data

Exhibit 12 summarizes average county-level industrial electricity prices by flow size category, which does not appear to vary significantly across the three key yes/no/not reported categories. The Region 4 data do not provide clear insight as to the effect of electricity cost on biogas utilization because prices are very similar for those that do and do not use biogas. For small and medium facilities in Texas, electricity cost may be a more important factor relative to other flow sizes and Region 4 overall. Texas facilities with 1 – 10 MGD flow that use biogas are in counties where average electricity prices that are 9% – 25% higher than facilities that do not use biogas. For reference, the cost to generate electricity using CHP at WRRFs can range from $11 – $83 dollars per megawatt-hour ($ per MWh) depending on the CHP prime mover and other factors.[21] Facilities have a greater incentive to use biogas for electricity generation if they are able to produce their own electricity for less than the cost of purchasing electricity.

Exhibit 12. Average County-Level Industrial Electricity Cost ($ per MWh)

Flow Size Category (MGD)	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
Region 4			
Less than 1	$57	NA	$66
1 - <5	$65	$64	$65
5 - <10	$66	$69	$68
10+	$69	$67	$62
Texas			
Less than 1	$45	$81	NA
1 - <5	$69	$63	$79
5 - <10	$79	$63	$79
10+	$64	$76	NA
NA = not applicable (no WRRFs in this category)			

As shown in Exhibit 13, Region 4 natural gas prices follow a more distinct pattern, with prices higher overall for facilities using biogas, compared to those that don't use biogas. This result is consistent with expectations given that natural gas consumption is frequently displaced by biogas consumption, and therefore, facilities facing higher gas cost may experience cost savings from deploying biogas systems. It should be acknowledged that future reporting consideration of actual energy content (such as MMBTU per cubic feet) can alleviate concern for potentially over-optimistic cost numbers for biogas. Note that since the natural gas price data are at the state-level, the secondary dataset is not currently able to differentiate gas prices for facilities with different biogas utilization responses. Industrial natural gas prices in Texas have

[21] U.S. EPA, Combined Heat and Power Partnership (CHPP), October 2011. Opportunities for Combined Heat and Power at Wastewater Treatment Facilities: Market Analysis and Lessons from the Field.

averages $5.72 per thousand cubic feet from 2003 to 2012, with an overall range of $3.02 to $8.96. These prices are overall lower than industrial gas prices for Region 4 states.

Exhibit 13. Region 4 Average 2003 – 2012 State-Level Industrial Natural Gas Cost ($ per thousand cubic feet)

Flow Size Category (MGD)	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
Less than 1	$7.69 (4.60-11.20)	NA	$8.90 (4.35-11.72)
1 - <5	$8.02 (4.30-12.10)	$7.86 (4.30-12.10)	$9.12 (6.82-11.72)
5 - <10	$8.33 (3.96-12.10)	$8.00 (4.35-11.72)	$9.06 (6.82-12.10)
10+	$8.34 (3.96-12.10)	$7.98 (4.30-11.72)	$7.92 (3.96-12.10)
Note: ranges in parentheses			

Exhibit 14 shows average state-level municipal sewer costs. The coarse resolution of the data (i.e., average state-level) limits the value. Insights based on wastewater costs can be improved by obtaining facility-specific values. Further – as with the natural gas data – expenditures in Texas cannot be differentiated by biogas utilization category and are therefore not included in the table. For reference, per capita sewerage expenditures in Texas averages $166, which is generally lower than Region 4 states.

Exhibit 14. Region 4 Average State-Level Government Sewerage Expenditures ($ per capita)

Flow Size Category (MGD)	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
Less than 1	$217	NA	$215
1 - <5	$183	$183	$229
5 - <10	$205	$171	$226
10+	$201	$196	$189
NA = not applicable (no WRRFs in this category)			

Landfill disposal costs are another key consideration for a facility considering anaerobic digestion and biogas use along with alternate approaches for managing biosolids. Exhibit 15 shows, again, anecdotally, that Region 4 facilities using biogas tend to be in states with higher landfill tipping fees across all flow size categories. Average state-level tipping fees in Texas are $28.60, again generally lower than fees for Region 4 states.

Exhibit 15. Region 4 Average 2013 State-Level Landfill Tipping Fees ($/ton)

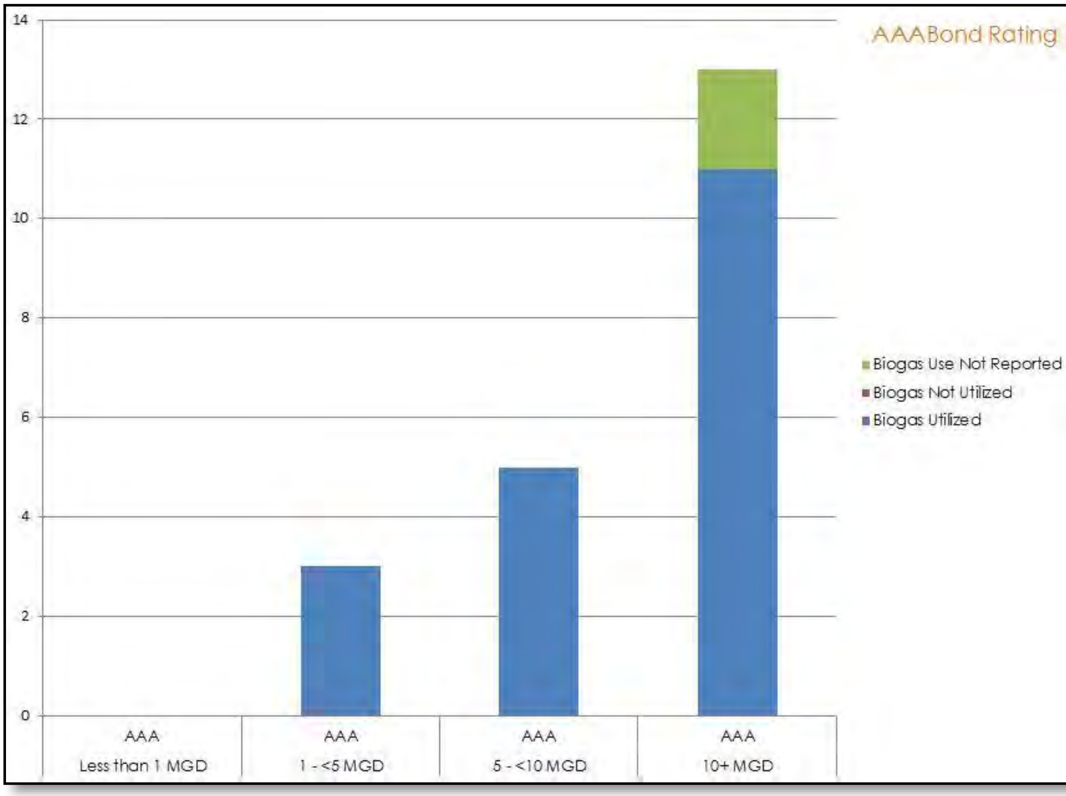
Flow Size Category (MGD)	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
Less than 1	$38.27	NA	$42.79
1 - <5	$40.20	$38.99	$43.65
5 - <10	$41.54	$35.91	$43.14
10+	$41.18	$40.53	$40.76
NA = not applicable (no WRRFs in this category)			

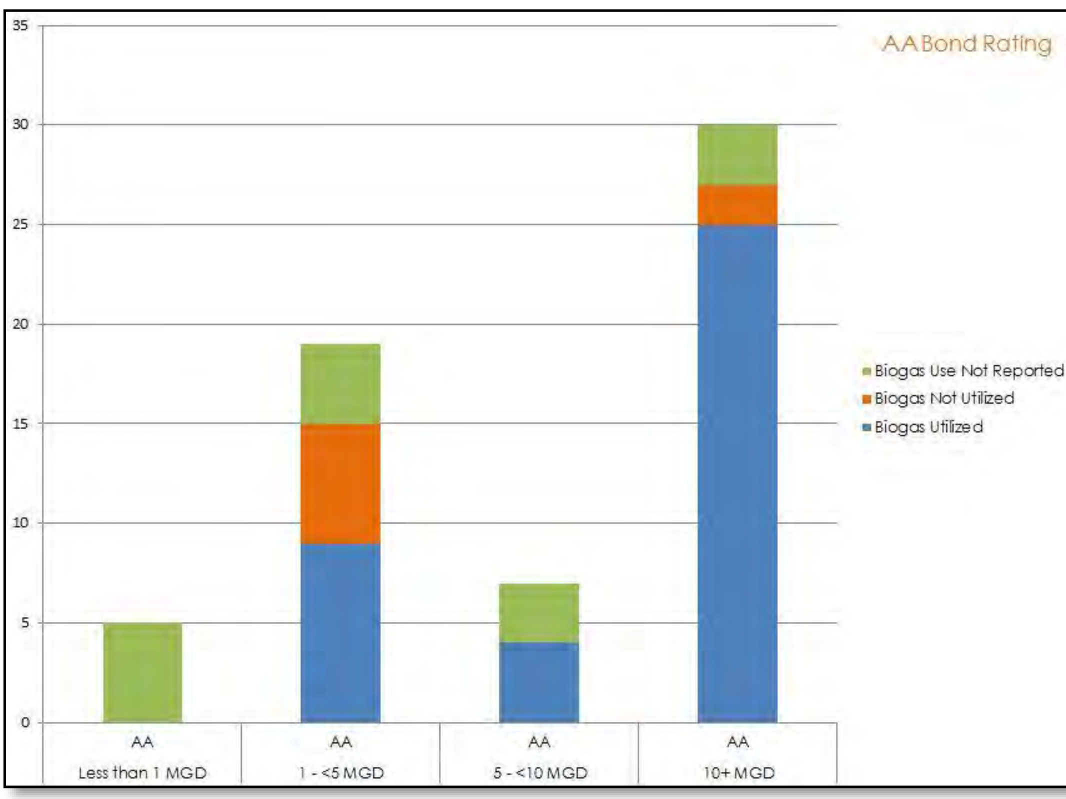
Exhibit 16 and Exhibit 17 present the bond rating data, at the county-level, and tend to support two expected outcomes: 1) that facilities that use biogas tend to have higher bond ratings compared to those that do not use biogas, and 2) that larger facilities tend to have higher bond ratings that smaller facilities. The first observation points to the greater potential for biogas project financing opportunities among higher-rated facilities, independent of facility size. The second observation illustrates a known challenge for small and medium facilities in obtaining financing relatively to large facilities.

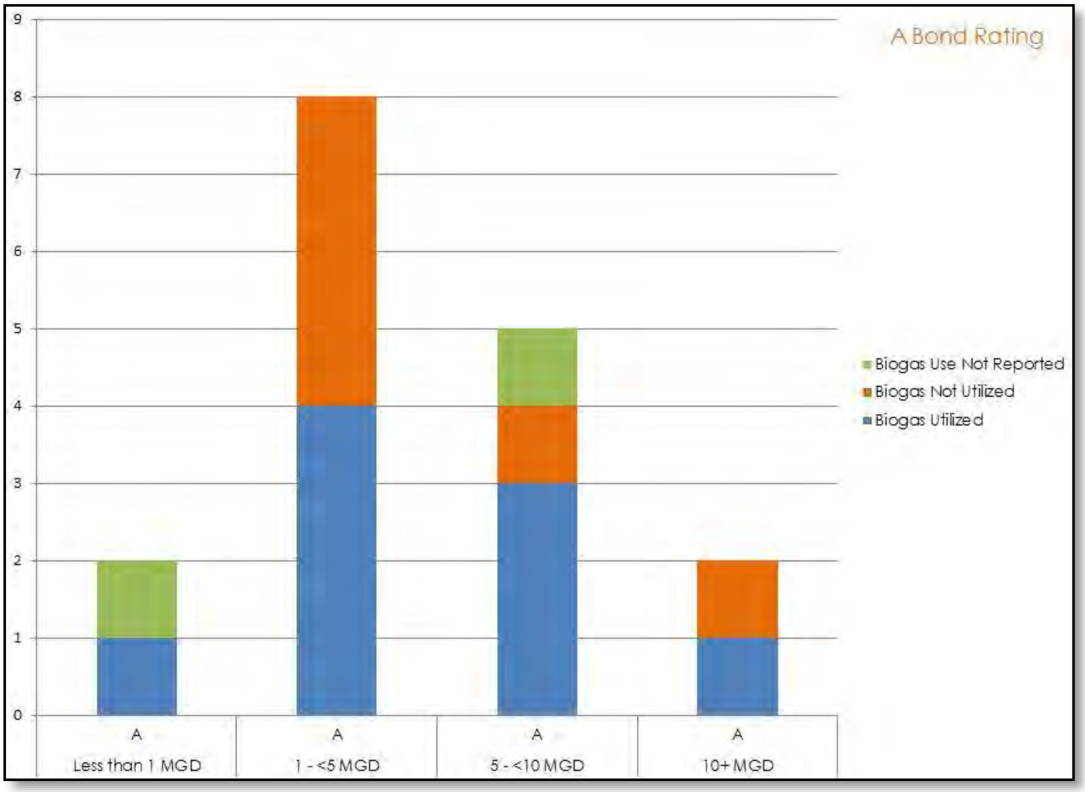
Exhibit 16. Number of Region 4 WRRFs Equipped with Anaerobic Digesters by Bond Rating

Bond Rating	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
Less than 1 MGD			
AAA	0	0	0
AA	0	0	5
A	1	0	1
BBB	0	0	0
Not available	0	0	1
1 - <5 MGD			
AAA	3	0	0
AA	9	6	4
A	4	4	0
BBB	1	1	0
Not available	1	0	0
5 - <10 MGD			
AAA	5	0	0
AA	4	0	3
A	3	1	1
BBB	2	1	0
Not available	3	1	0
10+ MGD			
AAA	11	0	2
AA	25	2	3
A	1	1	0
BBB	3	1	2
Not available	1	0	0

Number of Region 4 WRRFs Equipped with Anaerobic Digesters by Bond Rating






A Bond Rating
Biogas Use Not Reported
Biogas Not Utilized
Biogas Utilized
0
1
2
3
4
5
6
7
8
9
A
Less than 1 MGD
A
1 - <5 MGD
A
5 - <10 MGD
A
10+ MGD

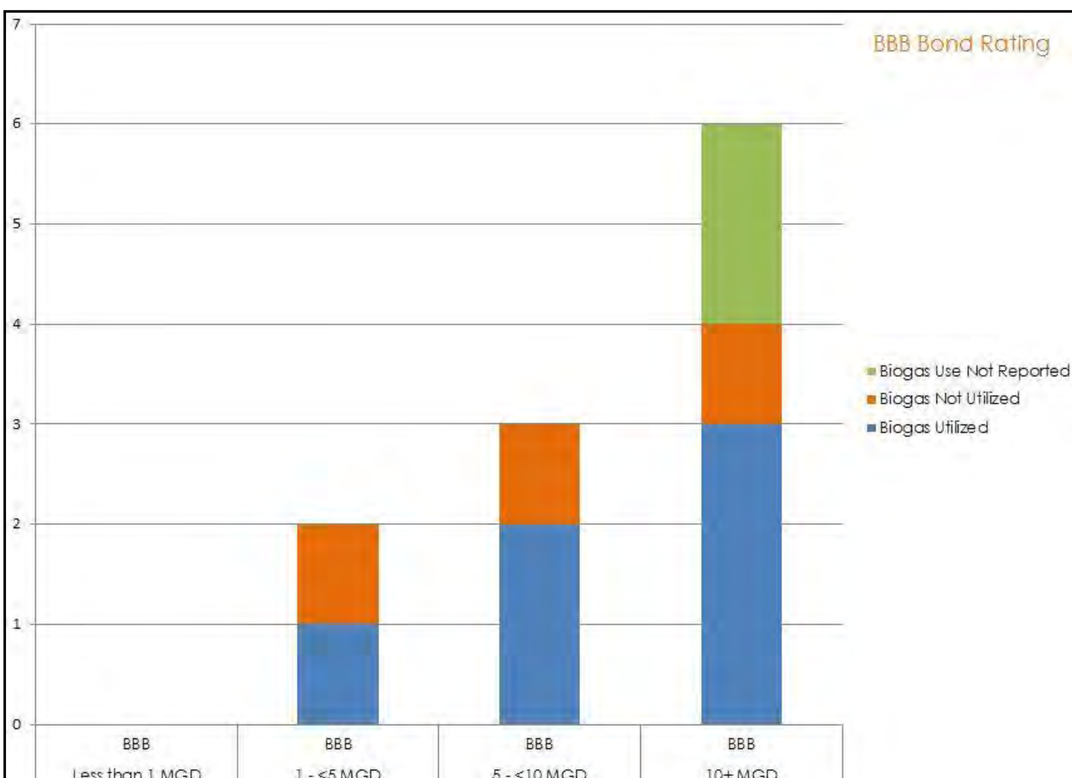

BBB Bond Rating
Biogas Use Not Reported
Biogas Not Utilized
Biogas Utilized
0
1
2
3
4
5
6
7
BBB
Less than 1 MGD
BBB
1 - <5 MGD
BBB
5 - <10 MGD
BBB
10+ MGD

Exhibit 17. Number of Texas WRRFs Equipped with Anaerobic Digesters by Bond Rating

Bond Rating	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
Less than 1 MGD			
AAA	0	0	0
AA	0	0	0
A	0	0	0
BBB	0	0	0
Not available	1	1	0
1 - <5 MGD			
AAA	0	1	0
AA	1	7	1
A	0	0	0
BBB	0	2	0
Not available	1	2	0
5 - <10 MGD			
AAA	0	0	0
AA	1	5	1
A	0	0	0
BBB	0	0	0
Not available	1	1	0
10+ MGD			
AAA	3	0	0
AA	8	0	0
A	1	1	0
BBB	1	0	0
Not available	1	0	0

4.2 Demographic Data

Exhibit 18 shows average county-level population estimates by WRRF flow category and biogas utilization status. In several categories (1 to 5 MGD in Region 4, 5 to 10 MGD in Texas, and 10+ MGD in both), biogas utilization is more prevalent in higher population counties. Average county populations are lower or similar in the remaining facility size categories across biogas utilization and no utilization.

Exhibit 18. Average County-Level Population

Flow Size Category (MGD)	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported[1]
Region 4			
Less than 1	63,829	NA	259,200
1 - <5	220,939	90,937	885,855
5 - <10	401,601	409,826	620,483
10+	780,873	420,941	586,328
Texas			
Less than 1	13,131	78,675	NA

Flow Size Category (MGD)	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported[1]
1 - <5	208,436	447,847	352,107
5 - <10	457,580	253,616	352,107
10+	1,278,784	19,859	NA

NA = not applicable (no WRRFs in this category)
1. As noted above, most of the <10 MGD Region 4 facilities in this category are part of JEA, and ship sludge to a regional biosolid handling facility that has anaerobic digesters and utilizes biogas. Several are in Duval County, FL, which has a population of 885,855, which tends to bias county-level population data upward.

Exhibit 19 and Exhibit 20 present county-level population growth and median income figures, neither of which appears to provide much explanatory power in observed differences in biogas use.

Exhibit 19. Average County-Level Population Growth Rate (2000 to 2010)

Flow Size Category (MGD)	Biogas Utilized	Biogas Use Not Utilized	Biogas Use Not Reported
Region 4			
Less than 1	10%	NA	35%
1 - <5	11%	12%	11%
5 - <10	13%	0%	11%
10+	12%	18%	14%
Texas			
Less than 1	-8%	7%	NA
1 - <5	17%	10%	9%
5 - <10	13%	16%	9%
10+	17%	-2%	NA

NA = not applicable (no WRRFs in this category)

Differences in median household income between facilities that do and do not use biogas are minimal in Region 4. In contrast, the Texas data show much larger differences and generally higher incomes in counties with facilities that use biogas, compared to counties where biogas is not utilized (e.g., $50k versus $45.3k in the 1 to 5 MGD category, and $48.9k versus $38.9k in the 10+ MGD category). This relationship reverses within the 5 to 10 MGD category in Texas, where counties served by biogas using facilities have lower incomes than counties served by similarly sized facilities that do not use biogas.

Exhibit 20. Average County-Level Median Household Income

Flow Size Category (MGD)	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
Region 4			
Less than 1	$40,655	NA	$57,631
1 - <5	$41,315	$41,369	$48,906
5 - <10	$45,813	$42,435	$46,113
10+	$47,312	$47,785	$48,127
Texas			
Less than 1	$42,271	$41,100	NA
1 - <5	$50,091	$45,254	$46,499
5 - <10	$39,925	$43,065	$46,499
10+	$48,896	$38,896	NA
NA = not applicable (no WRRFs in this category)			

4.3 Regulatory Data

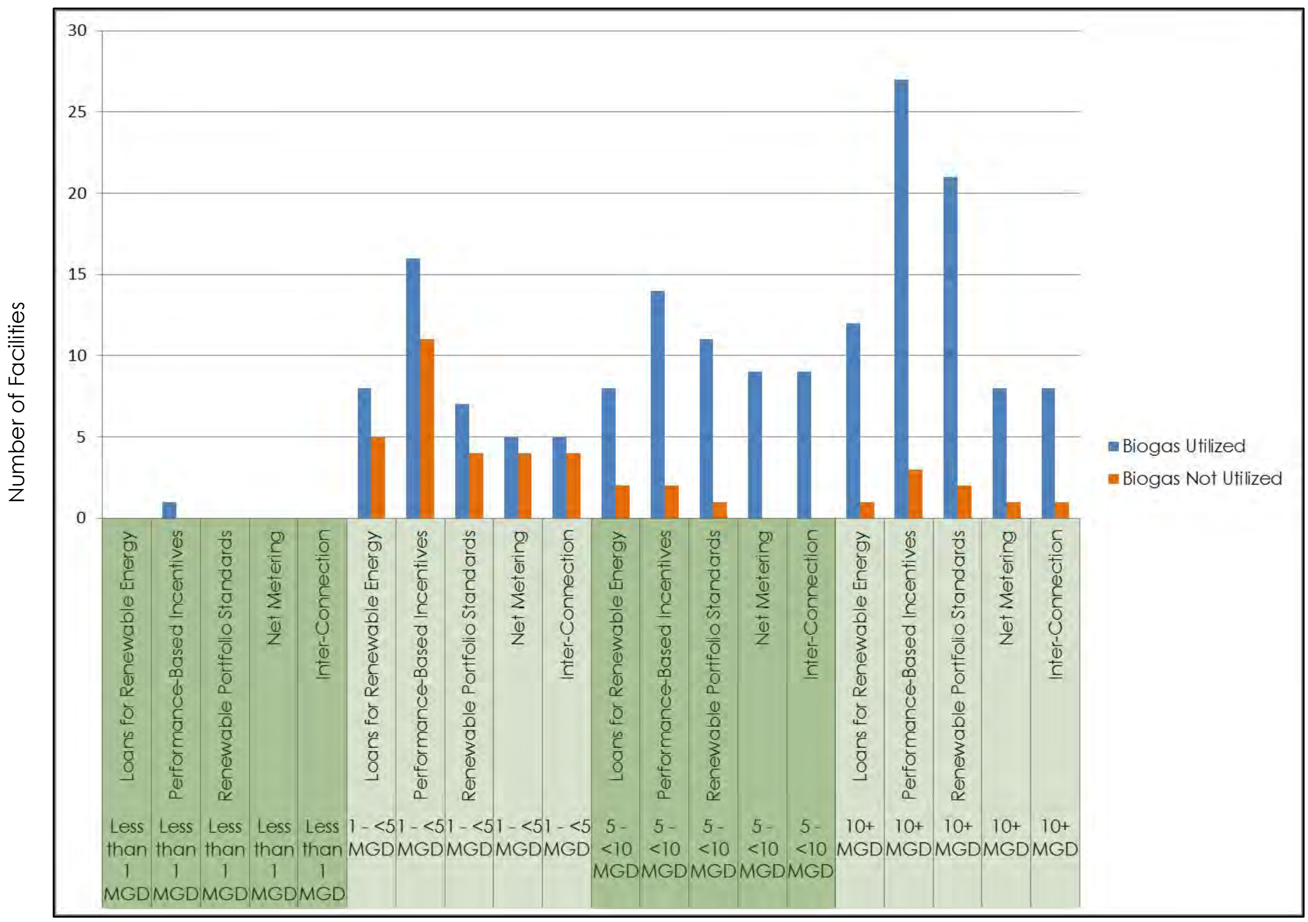
Exhibit 21 summarizes the number of facilities - by flow size and biogas use category - that are located in states that have different kinds of incentive policies and programs. For example, among Region 4 facilities with 5-10 MGD, 17 are located in states with performance-based incentives, and the vast majority of those (14) do use biogas. Comparing the biogas usage columns, and looking across flow size categories, these data indicate that facilities using biogas are much more likely to be in states that have policies/programs incenting biogas use. A similar analysis for Region 6 can be developed once additional Region 6 states are incorporated into the dataset.

Exhibit 21. Region 4 Regulatory and Incentive Program Effects on Biogas Utilization (for Different Size WRRFs)

Program	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
Less than 1 MGD			
Loans for Renewable Energy	0	0	1
Performance-Based Incentives	1	0	1
Renewable Portfolio Standards	0	0	6
Net Metering	0	0	0
Inter-Connection	0	0	0
1 - <5 MGD			
Loans for Renewable Energy	8	5	0
Performance-Based Incentives	16	11	0
Renewable Portfolio Standards	7	4	4
Net Metering	5	4	0
Inter-Connection	5	4	0

Program	Biogas Utilized	Biogas Not Utilized	Biogas Use Not Reported
5 - <10 MGD			
Loans for Renewable Energy	8	2	1
Performance-Based Incentives	14	2	1
Renewable Portfolio Standards	11	1	4
Net Metering	9	0	1
Inter-Connection	9	0	1
10+ MGD			
Loans for Renewable Energy	12	1	4
Performance-Based Incentives	27	3	6
Renewable Portfolio Standards	21	2	3
Net Metering	8	1	3
Inter-Connection	8	1	3

Region 4 WRRFs in States with Regulatory and Incentive Programs



5 Summary and Conclusions

The purpose of this effort is to collect and integrate secondary data into the existing WRRF database – currently for Region 4 and Texas – that may help explain differences in biogas utilization at WRRFs. These data do not account for all factors (particularly other plant-specific conditions) that can affect biogas utilization, but the data are useful for observing trends (or an absence of trends) in biogas utilization at WRRFs at an aggregate level.[22] States and other entities can then use information on both contributing and detracting factors to guide development of programs that may increase utilization.

The findings with respect to the secondary data for WRRFs in Region 4 and Texas are mixed. In some instances the data do suggest distinctions in secondary factors between facilities in different flow sizes and biogas utilization categories. These trends generally follow the expected intuition. For example, the data show – and one would expect – that facilities in relatively higher population counties are more likely to use biogas than systems in relatively smaller population counties. Larger population centers require relatively larger flow facilities, which provides for greater biogas production and utilization opportunities.

However, the data do not suggest that any of these secondary factors are limiting for biogas system utilization. While there are some intuitive patterns, overall the data demonstrate that WRRFs deploy biogas utilization systems across a range of economic and demographic conditions. For instance, facilities in Texas in the 5 to10 MGD flow category that use biogas are in lower- income counties compared to the 5 to 10 MGD facilities that do not use biogas. Among all secondary factors, the presence of supporting regulatory policies and programs in the facility's state indicates a relatively strong distinction between WRRFs that do and do-not use biogas in Region 4.

Additional findings on the specific secondary factors that were considered include:

- The use of AD at WRRFs and the use of biogas (among facilities using AD) are lower in TX compared to Region 4. Approximately 17% of Region 4 WRRFs indicate that they use AD, among facilities that provided information on AD. This percentage compares to 12% in Texas. In both regions, about 14% of all WRRFs did not report whether they use AD or not. In terms of biogas utilization among facilities with AD, 80% of Region 4 facilities use biogas compared to only 49% in Texas.
- Electricity cost may be a more important factor for small and medium facilities in Texas, relative to other flow sizes and Region 4 overall. Texas facilities with 1 to 10 MGD flow that use biogas are in counties with average electricity prices that are 9% to 25% higher than facilities that do not use biogas. Facilities have a greater incentive to use biogas for electricity generation if they are able to produce their own electricity for less than the cost of purchasing electricity.
- Region 4 natural gas prices indicate higher prices overall for facilities using biogas, compared to those that do not use biogas. This result is consistent with expectations given

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22 Abt Associates cannot extrapolate the data to make conclusions about what any particular WRRF may or may not do with respect to biogas utilization solely on the basis of secondary factors.

that natural gas consumption is frequently displaced by biogas consumption, and therefore, facilities facing higher gas cost may experience cost savings from deploying biogas systems.

- The coarse resolution of the per-capita sewer system expenditure data (i.e., average state-level) limits its value. Insights based on wastewater costs can be improved by obtaining facility-specific values.
- Region 4 facilities using biogas tend to be in states with higher landfill tipping fees across all flow size categories.
- Bond rating data tend to support two expected outcomes: 1) that facilities that use biogas tend to have higher bond ratings compared to those that do not use biogas, and 2) that larger facilities tend to have higher bond ratings than smaller facilities.
- In several categories (1 to 5 MGD in Region 4, 5 to 10 MGD in Texas, and 10+ MGD in both), biogas utilization is more prevalent in higher population counties.
- Among Region 4 facilities in the 5 to 10 MGD category, 17 are located in states with performance-based incentives, and the vast majority of those (14) do use biogas. Comparing the biogas usage columns, and looking across flow size categories, these data indicate that facilities using biogas are much more likely to be in states that have policies/programs incentivizing biogas use.

Appendix – Description of Energy Efficiency and Renewable Energy Policy and Incentive Categories

The Database of State Incentives for Renewables and Efficiency (DSIRE) organizes incentives and policies that promote renewable energy and energy efficiency into two general categories -- (1) Financial Incentives and (2) Rules, Regulations & Policies. The specific incentive and policy categories are described below.[23]

FINANCIAL INCENTIVES

Grant programs offered by States include programs to encourage the use and development of renewables and energy efficiency. Most programs offer support for a broad range of technologies, while a few programs focus on promoting a single technology, such as photovoltaic (PV) systems. Grants are available primarily to the commercial, industrial, utility, education and/or government sectors. Most grant programs are designed to pay down the cost of eligible systems or equipment. Others focus on research and development, or support project commercialization. In recent years, the federal government has offered grants for renewables and energy efficiency projects for end-users. Grants are usually competitive.

Green buildings are designed and constructed using practices and materials that minimize the impacts of the building on the environment and human health. Many cities and counties offer financial incentives to promote green building. The most common form of incentive is a reduction or waiver of a building permit fee. Several organizations issue certification for green buildings, including the U.S. Green Building Council (LEED certification), the Green Building Initiative (Green Globes certification), and the NAHB Research Center (National Green Building Certification). (Note that this category includes green building incentives that do not fall under other DSIRE incentive categories, such as tax incentives and grant programs.)

Loan programs provide financing for the purchase of renewable energy or energy efficiency systems or equipment. Low-interest or zero-interest loans for energy efficiency projects are a common demand-side management (DSM) practice for electric utilities. State governments also offer low-interest loans for a broad range of renewable energy and energy efficiency measures. These programs are commonly available to the residential, commercial, industrial, transportation, public and/or non-profit sectors. Loan rates and terms vary by program; in some cases, they are determined on an individual project basis. Loan terms are generally 10 years or less. In recent years, the federal government has offered loans and/or loan guarantees for renewables and energy efficiency projects.

Performance-based incentives (PBIs), also known as production incentives, provide cash payments based on the number of kilowatt-hours (kWh) or BTUs generated by a renewable energy system. A "feed-in tariff" is an example of a PBI. To ensure project quality, payments based on a system's actual performance are generally more effective than payments based on a system's rated capacity. (Note that tax incentives based on the amount of energy produced

[23] Source: http://www.dsireusa.org/

by an eligible facility are categorized as "Corporate Tax Incentives" or "Personal Tax Incentives" in DSIRE.)

RULES, REGULATIONS, and POLICIES

Building energy codes adopted by states (and some local governments) require commercial and/or residential construction to adhere to certain energy standards. While some government entities have developed their own building energy codes, many use existing codes (sometimes with state-specific amendments), such as the International Energy Conservation Code (IECC), developed and published by the International Code Council (ICC); or ASHRAE 90.1, developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). A few local building energy codes require certain commercial facilities to meet green building standards.

Energy efficiency resource standards (EERS) are state policies that require utilities to meet specific targets for energy savings according to a set schedule. EERS policies establish separate reduction targets for electricity sales, peak electric demand and/or natural gas consumption. In most cases, utilities must achieve energy savings by developing demand-side management (DSM) programs, which typically provide financial incentives to customers to install energy-efficient equipment. An EERS policy is sometimes coupled with a state's renewables portfolio standard (RPS). In these cases, energy efficiency is typically included as a lower-tier resource. EERS policies are also known as Energy Efficiency Portfolio Standards (EEPS).

Energy standards for public buildings implemented by many states and local governments, as well as the federal government, require new government buildings to meet strict energy standards. DSIRE includes policies that have established green building standards, energy-reduction goals, equipment-procurement requirements, and/or the use of on-site renewable energy. Many of these policies require that new government buildings (and renovated buildings, in some cases) attain a certain level of certification under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program. Equipment-procurement policies often mandate the use of the most efficient equipment, including equipment that meets federal Energy Star criteria. Policies designed to encourage the use of on-site renewables generally establish conditional requirements tied to life-cycle cost analysis.

Interconnection standards specify the technical and procedural process by which a customer connects an electricity-generating system to the grid. Such standards include the technical and contractual terms to which system owners and utilities must abide. State public utilities commissions typically establish standards for interconnection to the distribution grid, while the Federal Energy Regulatory Commission (FERC) has adopted standards for interconnection to the transmission level. While many states have adopted interconnection standards, some states' standards apply only to investor-owned utilities (and not to municipal utilities or electric cooperatives).

Net metering allows for the flow of electricity both to and from the customer – typically through a single, bi-directional meter. When a customer's generation exceeds the customer's use, electricity from the customer flows back to the grid, offsetting electricity consumed by the customer at a different time during the same billing cycle. In effect, the customer uses excess generation to offset electricity that the customer otherwise would have to purchase at the utility's full retail rate. Net metering is required by law in most U.S. states, but state policies vary widely.

Public benefit funds (PBF) were developed by states during the electric utility restructuring era, in the late 1990s, to ensure continued support for renewable energy, energy efficiency and low-income energy programs. These funds are commonly supported through a very small surcharge on electricity consumption (e.g., $0.002/kWh). This charge is sometimes referred to as a "system benefits charge" (SBC). PBFs commonly support rebate programs, loan programs, research and development, and energy education programs.

Renewable portfolio standards (RPS) require utilities to use or procure renewable energy or renewable energy credits (RECs) to account for a certain percentage of their retail electricity sales -- or a certain amount of generating capacity -- according to a specified schedule. (Renewable portfolio goals are similar to RPS policies, but goals are not legally binding.) Most U.S. states have established an RPS. The term "set-aside" or "carve-out" refers to a provision within an RPS that requires utilities to use a specific renewable resource (typically solar energy) to account for a certain percentage of their retail electricity sales (or a certain amount of generating capacity) according to a set schedule.


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