# Appendix 4-2. Digester Gas Utilization

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## 1.1 DIGESTER GAS UTILIZATION

As discussed in the previous sub-section, there are three separate destinations for digester gas: The dryers, the boilers, or the flare. Figure 1-1 represents the relative volume of digester gas used by the three processes.

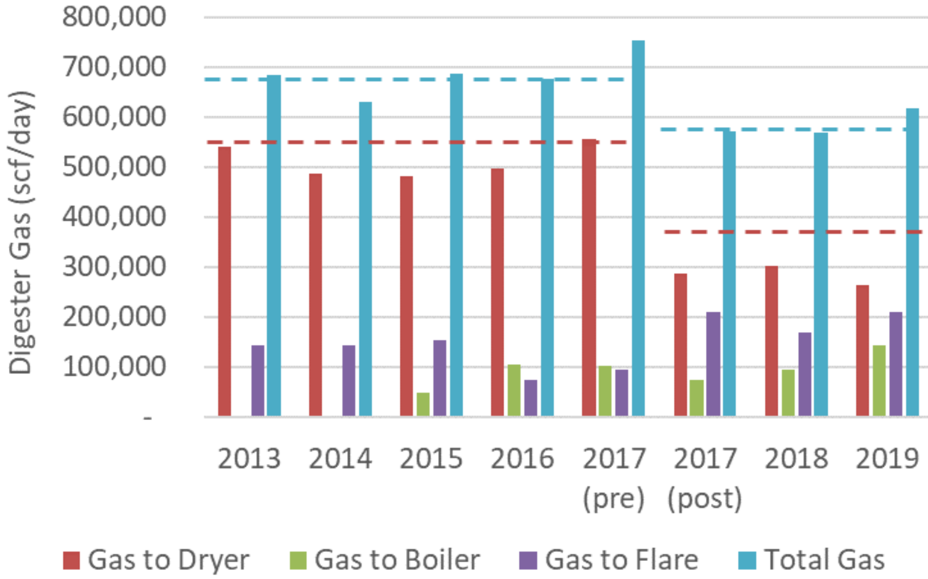


Figure 1-1: Digester Gas Meter Flows (2013-2019)

Prior to the meter replacement in 2017, the vast majority of digester gas was used by the dryers. While the graph also includes the estimated 101,000 scfd inaccurately measured by the dryer gas meter, flow to the dryer is shown as using an average 74,000 scfd more than the flare each year. After the meter replacement, the dryer is still the main recipient of digester gas, but since 2017, it is more closely matched by the volume of gas flared.

Digester gas is flared when either an excess of gas is produced and it exceeds the demand of the dryer and boilers, or when the dryer is switched to run on natural gas. In order to gain a better understanding of how frequently the dryer fuel source is switched from digester gas to natural gas, a sample period of time was analyzed from April 10th to May 30th of 2018.

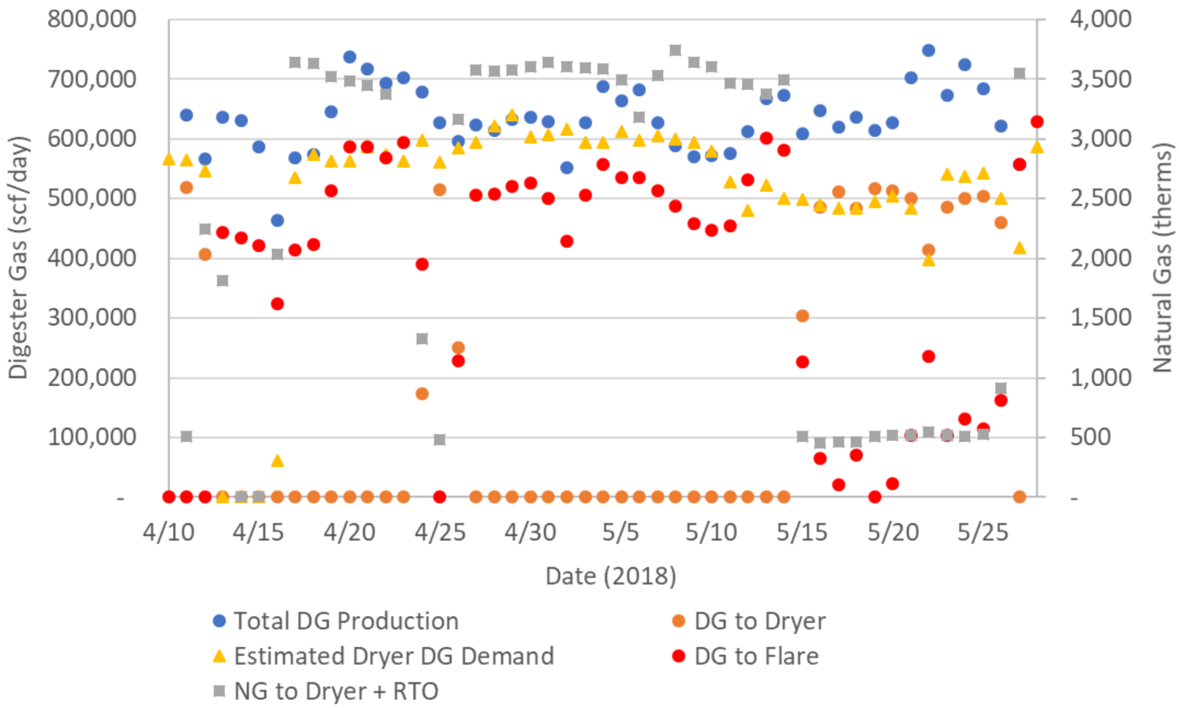


Figure 1-2: Daily Representation of Dryer Fuel Source

Figure 1-2 plots the volume of digester gas used by the dryer as shown on the primary y-axis as well as the actual quantity natural gas used by the dryer and RTO combined as measured in therms on the secondary y-axis. In addition, an estimated digester gas demand for the dryer was calculated based on the loading of the centrifuge, an average centrifuge cake solids content of 19%, and an assumed dryer fuel requirement of 20,000 therms/dry ton. It was assumed that the RTO requires an average of 500 therms per day based on the prolonged period in late May when the dryer was running exclusively on digester gas and all the natural gas metered went to the RTO. Lastly, the figure provides an estimate for the dryer digester gas demand based on the natural gas consumption on days when the dryer is running exclusively on natural gas.

The data included in Figure 1-2 demonstrates that there were several extended periods of time where the dryer was exclusively fueled by natural gas, and a majority of digester gas generated was flared. It also suggests that the total digester gas volume produced nearly always exceeds the estimated digester gas demand of the dryer. When the gas utilization volumes are broken down by quarter (Figure 1-3), there are some extended periods of time where more gas is flared than it is utilized by the dryer.

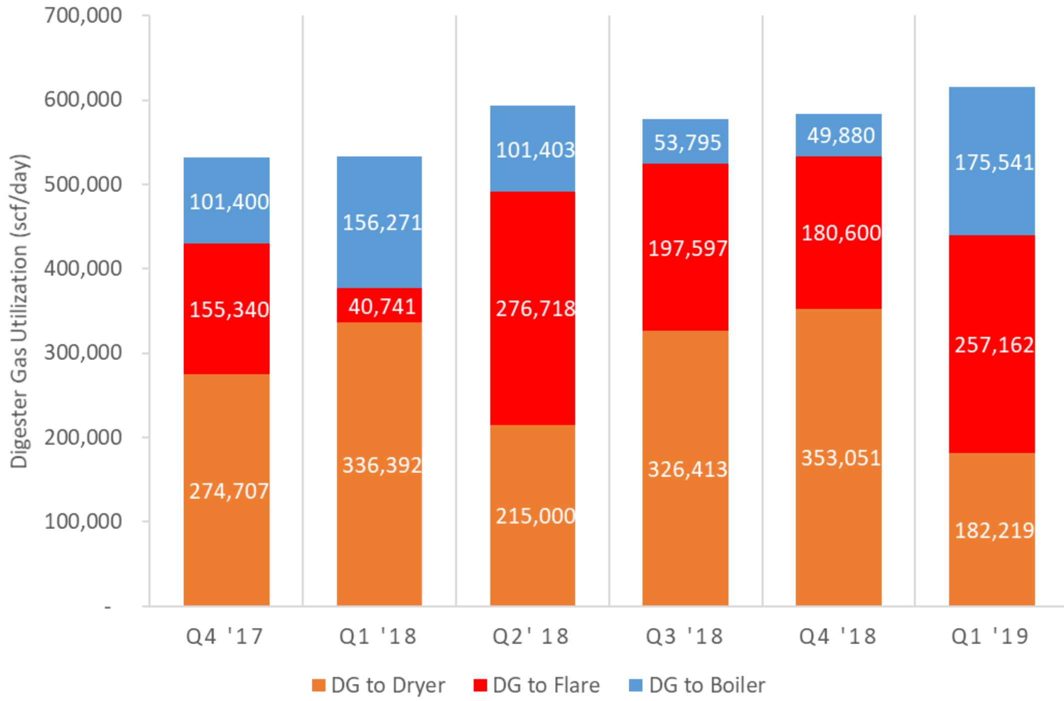


Figure 1-3: Digester Gas Utilization (Q4 ’17 - Q1 ‘19)

NEFCO is responsible for running the dryer, along with all other equipment in the final stabilization building. When asked why the dryer fuel source would be switched from digester gas to natural gas, three reasons were given: low digester gas availability, high RTO pressure differential, and low RTO flame temperature. When digester gas is used to operate the boilers (primarily in in Q1 and Q2), occasionally the volume of remaining gas is less than the digester gas required to operate the dryer. The other two issues are both limitations related to the RTO.

The RTO (regenerative thermal oxidizer) receives the dryer exhaust gas and raises the temperature high enough to break down undesirable contaminants. Energy generated by the high temperature flame is recovered upon discharging the gas by ceramic media within the RTO unit. When gas is next received by the unit, the intake flows through the hot ceramic media, preheating the air stream before it reaches the combustion chamber. Over time, the media becomes fouled by the exhaust air, and the pressure required to pass through the media increases.

Digester gas has a methane content that can range anywhere from 55-70%, while the methane content of natural gas is approximately 87%. The lower energy content of digester gas means a larger volume is required by the dryer to achieve the same thermal capacity. More gas combusted results in a larger exhaust volume, which results in a higher pressure drop across the media in the RTO. Switching from digester gas to natural gas means the RTO receives a lower volume of exhaust, requiring less pressure to pass through the media.

In addition to increasing the pressure differential within the RTO, the larger volume of dryer exhaust generated by digester gas requires more thermal energy to bring the combustion flame up to the target temperature. If the RTO flame doesn't achieve a target temperature, some contaminants aren't completely broken down, and would be released into the atmosphere.

In order to determine how the digester gas volume is the factor limiting its use in the dryer, the actual volume of natural gas used by the dryer and RTO was analyzed alongside the volume of cake dried by the natural gas to identify the hypothetical volume of digester gas that would be required for the equivalent drying. Table 1-1 compares the estimated digester gas required to the volume produced during the same time period, identifying the fraction of the dryer demand that could be met.

Table 1-1: Natural Gas Usage, Cake Loading and Dryer Energy Requirements

| MONTH/YEAR | NG USAGE (THERMS/MO) | CAKE DRIED WITH NG (DT/MO) | CAKE LOADING (DT/MO) | DG REQUIRED (SCF/DAY) | DG PRODUCED (SCF/DAY) | DEMAND MET (%) | EST. DAYS DRIED W/ DG | EST. DAYS DRIED W/ NG |
|---|---|---|---|---|---|---|---|---|
| 2013 | 19,678 | 148 | 651 | - | - | - | - | 6.8 |
| 2014 | 17,815 | 134 | 700 | - | - | - | - | 5.7 |
| 2015 | 14,605 | 110 | 694 | - | - | - | - | 4.7 |
| Sep-17 | 78,704 | 591 | 720 | 480,000 | 544,776 | 113% | 9 | 21 |
| Oct-17 | 43,070 | 323 | 750 | 484,000 | 541,901 | 112% | 18 | 13 |
| Nov-17 | 50,952 | 382 | 636 | 424,000 | 519,730 | 123% | 16 | 14 |
| Dec-17 | 28,533 | 214 | 663 | 428,000 | 532,332 | 124% | 23 | 8 |
| Jan-18 | 36,752 | 276 | 787 | 508,000 | 511,894 | 101% | 20 | 11 |
| Feb-18 | 30,947 | 232 | 608 | 434,000 | 501,576 | 116% | 20 | 8 |
| Mar-18 | 27,135 | 204 | 704 | 454,000 | 578,478 | 127% | 25 | 6 |
| Apr-18 | 56,228 | 422 | 579 | 386,000 | 612,434 | 159% | 10 | 20 |
| May-18 | 66,227 | 497 | 822 | 530,000 | 637,328 | 120% | 12 | 19 |
| Jun-18 | 22,083 | 166 | 747 | 498,000 | 528,662 | 106% | 18 | 12 |
| Jul-18 | 41,547 | 312 | 884 | 570,000 | 596,448 | 105% | 18 | 13 |
| Aug-18 | 39,133 | 294 | 772 | 498,000 | 580,739 | 117% | 20 | 11 |
| Sep-18 | 38,325 | 288 | 687 | 458,000 | 559,914 | 122% | 21 | 9 |
| Oct-18 | 37,843 | 284 | 651 | 420,000 | 545,752 | 130% | 20 | 11 |
| Nov-18 | 48,687 | 365 | 579 | 386,000 | 596,419 | 155% | 24 | 6 |
| Dec-18 | 27,997 | 210 | 744 | 480,000 | 604,831 | 126% | 30 | 1 |
| Jan-19 | 44,017 | 330 | 744 | 480,000 | 629,437 | 131% | 21 | 10 |
| Feb-19 | 71,677 | 538 | 672 | 480,000 | 625,487 | 130% | 14 | 14 |

From September ’17 to February ’19, the dryer was fueled by natural gas approximately 11.5 days each month (36%). During the same period, the digesters produced an average of 23% more digester gas than would be required to operate the dryers on digester gas. There wasn’t a single month where the digester gas produced was less than the hypothetical demand from the dryers. This suggests that the main limiting factor in utilizing digester gas for drying is the exhaust treatment capacity of the RTO.

## 1.2 DIGESTER GAS METHANE CONTENT

When digester gas is generated by mesophilic bacteria, the methane content can vary significantly. The methane content of digester gas is important for the thermal value of the gas, but it also is indicative of the digester health as well. Figure 1-4 is a plot of the methane content of digester gas at Blue Lake WWTP.

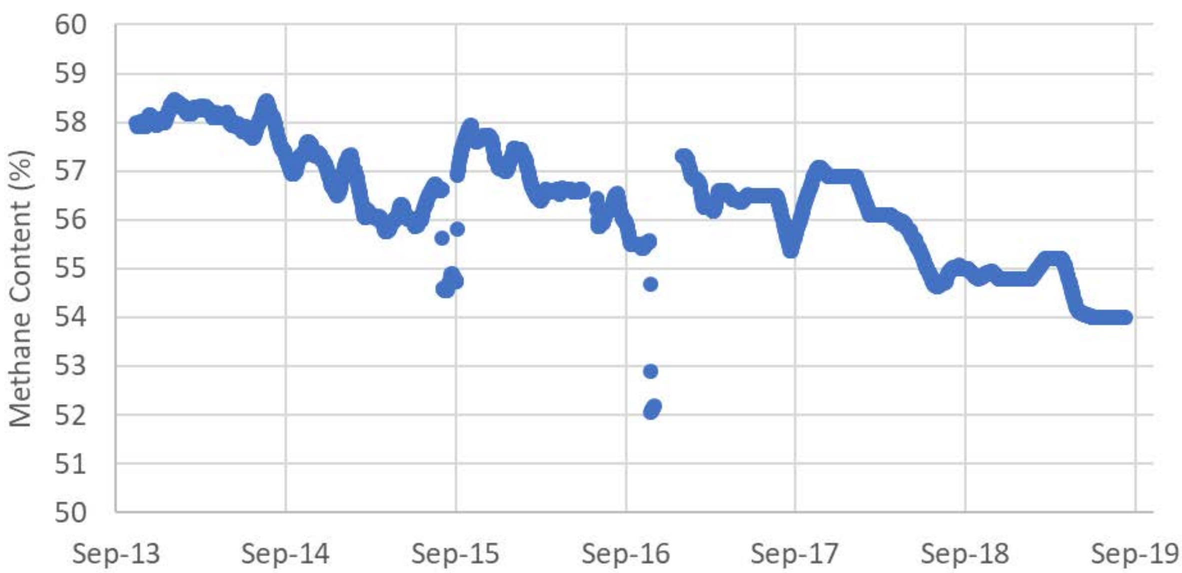


Figure 1-4: Digester Gas Methane Content (2013-2019)

The historic methane content shows a clear downward trend from 2013 to 2019. Soon after the digesters were brought online in 2011, the methane content was approximately 58%. The methane content remained consistent for approximately a year before it began a gradual decline, eventually flattening out at 54% in mid-2019.

As discussed earlier, the methane content of digester gas can range anywhere from 55-70%, but if the content starts to trend downward it typically means one of three things:

1. Air intrusion – If there is a leak in the membrane, air can infiltrate the headspace of the digesters and dilute the digester gas.

2. VA/A ratio and pH of the digester - A higher volatile fatty acid to alkalinity (VA/A) ratio yields a lower methane content, and a lower pH will produce more $CO_2$ relative to methane.

3. Increased HRT – A longer residence time may result in a larger overall gas yield, but the methane content will decline.

Air intrusion is very unlikely at Blue Lake WWTP, as the sludge holding tank has a double membrane cover with a Dystor® system actively monitoring the interstitial space between the systems for leaks.

The VA/A ratio in the three digesters has gradually trended up over time (see Figure 1-5), but the rises and dips don't correspond to changes in the methane content, and the VA/A ratio is within reasonable limits. It is possible the increase could cause a reduction in methane content but testing this hypothesis would mean a significant addition of alkalinity to the process over a prolonged period of time.

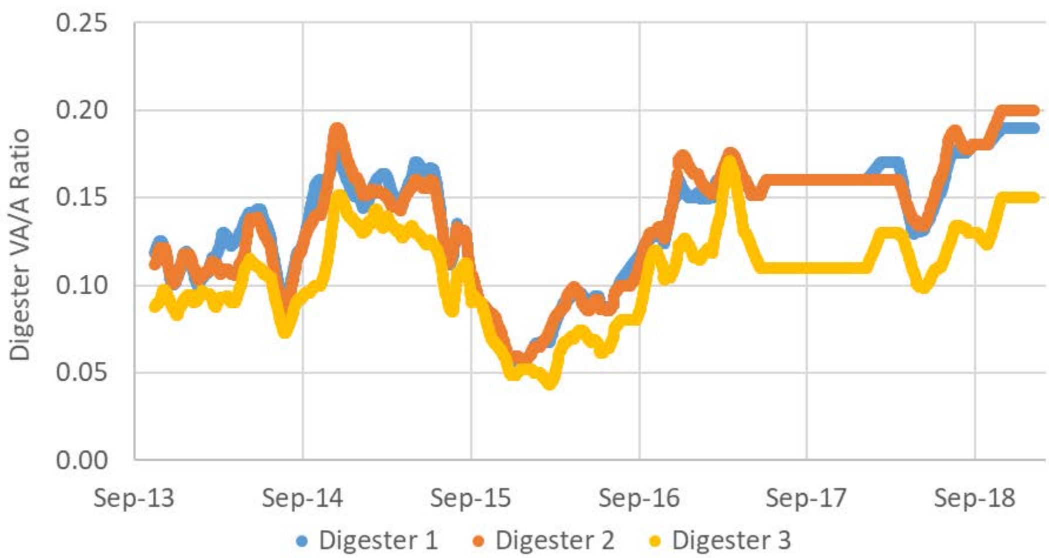


Figure 1-5: Digester Volatile Acid/Alkalinity Ratio (2013-2019)

The pH in the three digesters has gradually trended downward over time (see Figure 1-6), but the overall change is insignificant, and also hasn't correlated with the shifts in digester gas methane content.

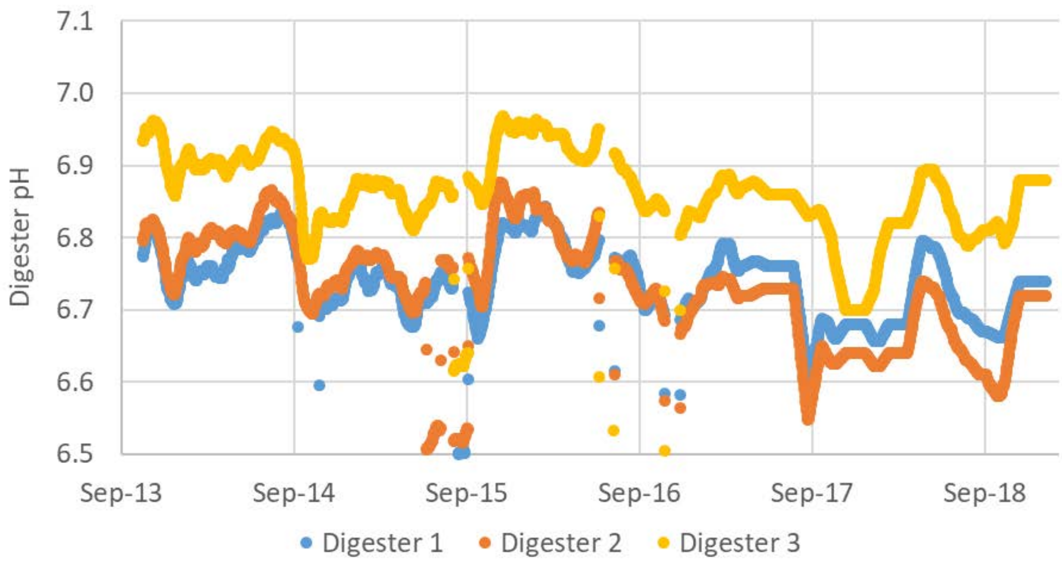


Figure 1-6: Digester pH (2013-2019)

The last metric considered was the hydraulic residence time (HRT). Figure 1-7 contrasts the methane content to the HRT of both digesters 1 and 2. As the HRT has decreased gradually since August of 2016, the methane content recorded also decreased, which is the opposite of what would be expected. This suggests the HRT changes aren't significant enough to impact the methane content of the digester gas.

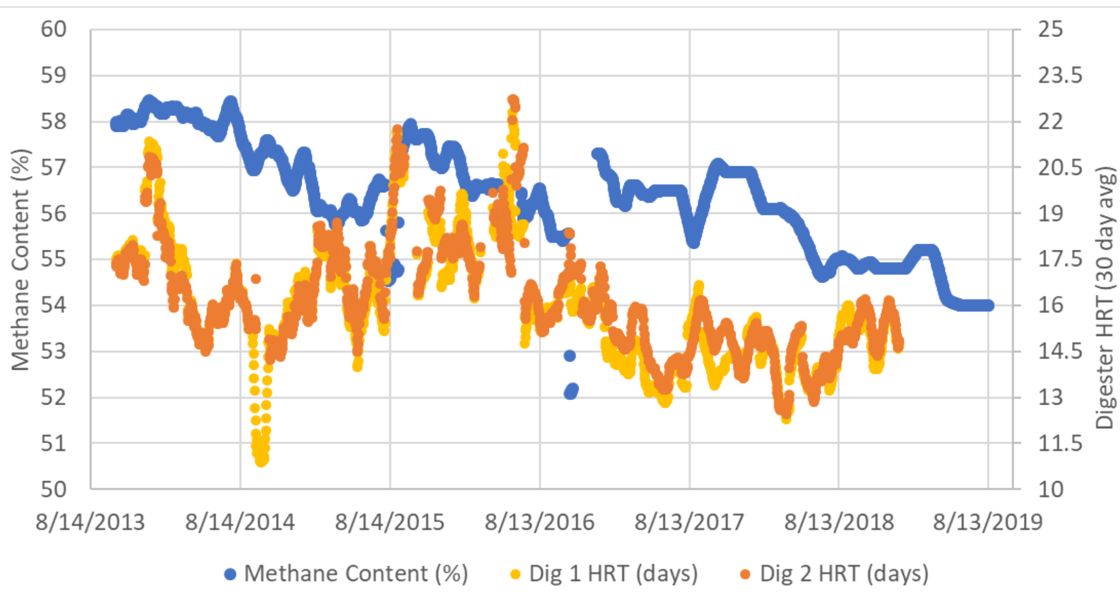


Figure 1-7: Digester HRT vs. Methane Content

As none of the typical indicators strongly suggested a decrease in methane content, MCES looked into the issue. The MCES process group discovered that when they compared the measurement performance of the methane meter at Blue Lake WWTP to that of known accurate meter, it was determined the plant meter is reading approximately 3.1% low. Based on the results of the known accurate meter, the methane content of digester gas at Blue Lake WWTP is currently approximately 57%, indicating the decline represented by Figure 1-4 is incorrect.